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COMMON INSECTS & DISEASES of
Forest Trees In The NORTHEASTERN UNITED STATES

FOREST INSECT AND DISEASE MANAGEMENT
FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE
NORTHEASTERN AREA, STATE AND PRIVATE FORESTRY
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COVER PHOTOS

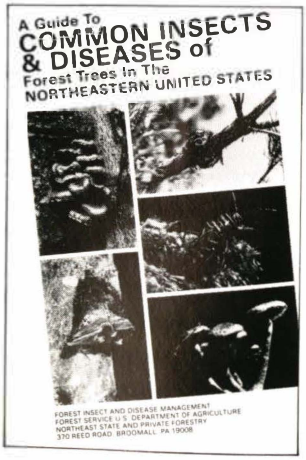
Mushrooms of *Pholiota* (upper left)

Mushrooms of *Armillariella mellea* (lower right)

Aecia on Scots pine — eastern gall rust (upper right)

Adult locust borer (middle right)

Conk of *Phellinus igniarius* (lower left)



A Guide To
COMMON INSECTS
& DISEASES of
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A GUIDE TO COMMON INSECTS AND DISEASES OF FOREST TREES IN THE NORTHEASTERN UNITED STATES

FOREST INSECT AND DISEASE MANAGEMENT NA-FR-4
1979
FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE
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ACKNOWLEDGMENTS

We wish to extend our appreciation to the staff of the Office of Information, Eastern Region, USDA Forest Service for their role in producing this publication. We also gratefully acknowledge the contributions of the many state forestry agencies, universities, and private individuals who assisted in the preparation of this guide.

INTRODUCTION

This guide will assist forest landowners and managers in identifying many common forest pests in the northeastern United States. It emphasizes forest insects and diseases, but includes some weather factors, vertebrate animals, nematodes and mites.

The guide is organized so that insects and diseases of hardwoods are found in one section, insects and diseases of conifers in another, and other pests and damage agents that affect trees in a third section. Within the hardwood and conifer sections, insects and diseases are arranged according to the portion of the tree they attack: foliage, stem, and root and root collar. Color photographs are included to aid in identification of forest pests and damage source.

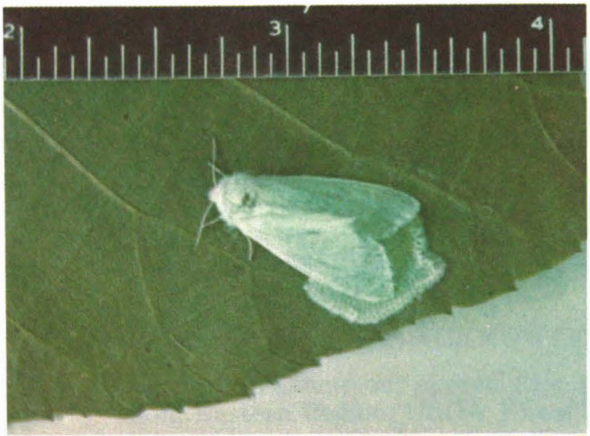
Common names of forest pests and their hosts have been used whenever possible. The names for insects follow those listed by the Entomological Society of America, 1978 (Special Publication 78-1), or those widely used and accepted by forest entomologists. The scientific names for fungi follow Hepting, 1971 (U.S. Dept. of Agriculture Handbook 386) unless a more recent publication indicates that another name should be used. A glossary has been included to define technical terms.

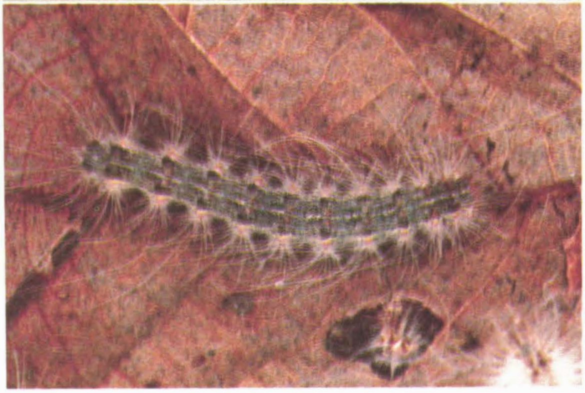
FALL WEBWORM *Hyphantria cunea*

In autumn, fall webworm colonies attack ash, black walnut, hickory, oak, and other hardwoods, enveloping the ends of branches with large, unsightly webs. Because defoliation comes late in the growing season, fall webworm damage usually is considered serious only where esthetic values are important. Its host list includes more than 100 tree species.

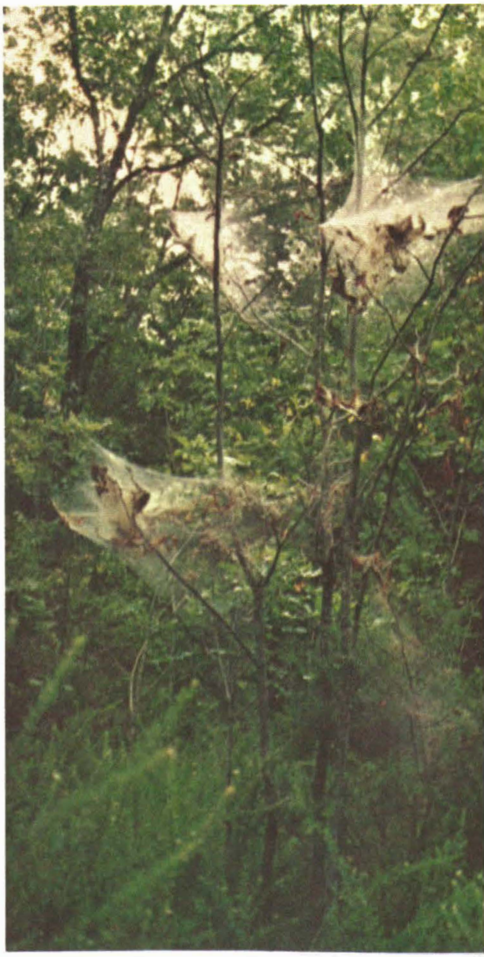
The adult moths appear from May to July, and soon deposit hair-covered masses of several hundred eggs, usually on the undersides of leaves. The moths vary in color from white with dark spots on the wing to pure white. The larvae, which are covered with long, gray hairs, are pale yellow, brown or green, with a broad, dusky stripe down each side. They usually do not entirely consume the leaves, but skeletonize them to such an extent that the leaves curl, dry up, and eventually die. The larvae feed gregariously until the last instar. After feeding, the larvae drop to the ground where they pupate in the duff or the upper surface of the soil. There are one or two generations per year, depending on location.

Adult female ▼





Larva ▲



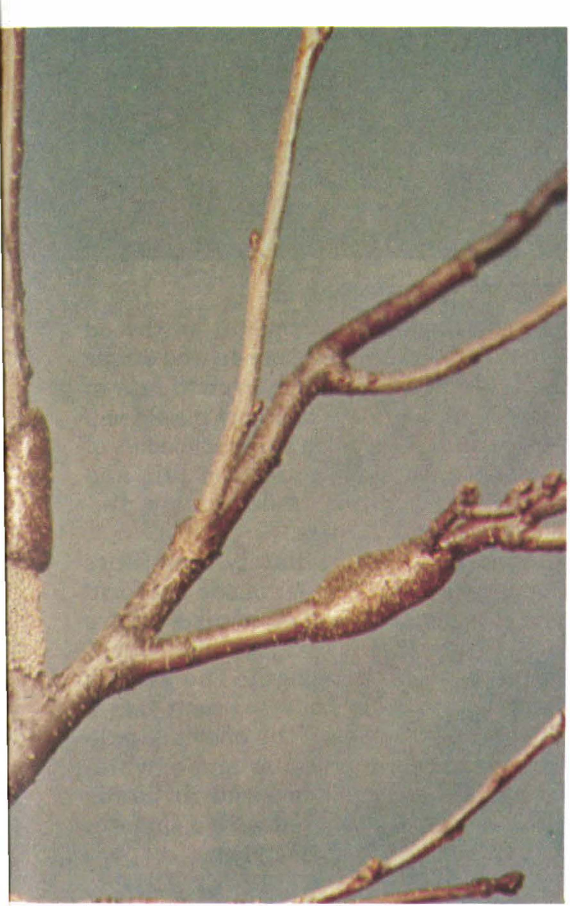
Larval webbing ▲

EASTERN TENT CATERPILLAR *Malacosoma americanum*

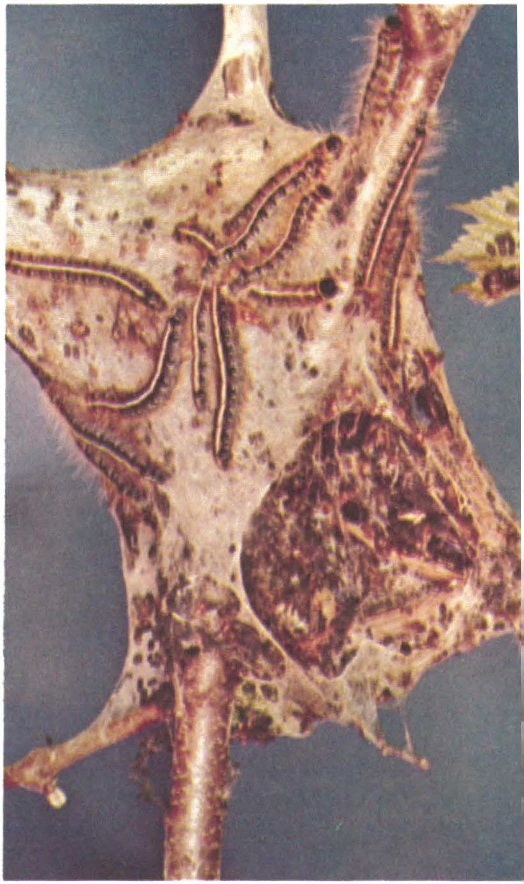
The eastern tent caterpillar is a late-spring defoliator of many hardwood tree species. In addition to the damage caused by defoliation, the dirty, silken tents — which are filled with frass and cast larval skins — can ruin the appearance of ornamentals. The preferred hosts of this insect are wild cherry and abandoned apple trees, but it also attacks many other species of forest, shade, and fruit trees.

Caterpillars emerge from the eggs in early spring, about when buds are opening. After a short feeding period, caterpillars from one or more egg mass spin a tent in a tree crotch. This tent enlarges as the caterpillars grow. A mature caterpillar, 2 to 2½ inches long, is black with a continuous white stripe along the middle of the back, bordered on each side by a broken reddish-brown line. Each segment has a small, vertical blue mark on the side.

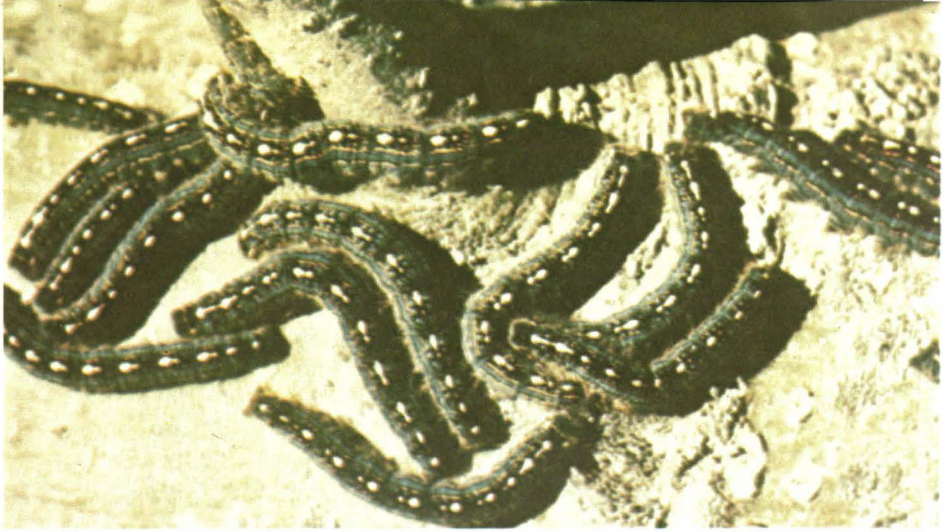
Pupation occurs within a loosely woven, whitish-yellow cocoon. The adults emerge in early summer, depositing their eggs in bands around small twigs of host trees. The brownish egg masses have hard, shiny coverings. The larvae do not emerge until the following spring. There is one generation per year.



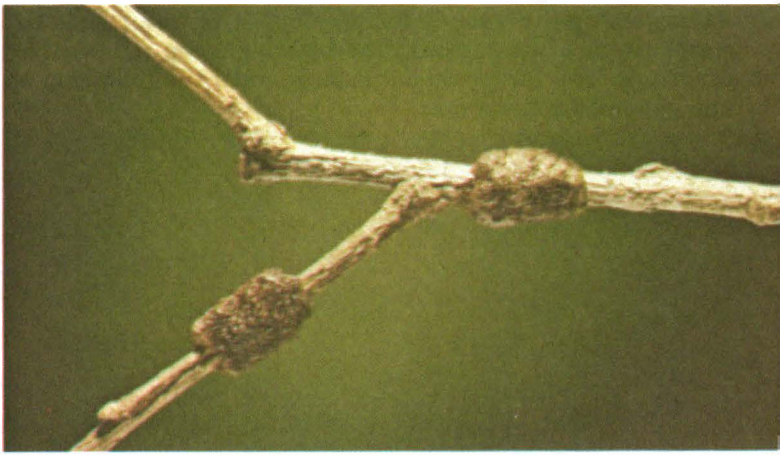
Egg masses ▲



Larvae on tent ▲



▲
Larvae



Egg masses ▶

FOREST TENT CATERPILLAR *Malacosoma disstria*

Forest tent caterpillar is an early-season defoliator of several hardwood species. In its northern range, where it feeds on quaking aspen and sugar maple, tree mortality is generally not extensive. However, growth loss in aspen may be considerable, and quantity and quality of sugar maple sap may be reduced. In its southern range, where it feeds on several species of gum and oak, heavy defoliation can produce substantial top kill and mortality of water tupelo and blackgum. In addition to defoliation, migrating caterpillars can be a nuisance to recreationists.

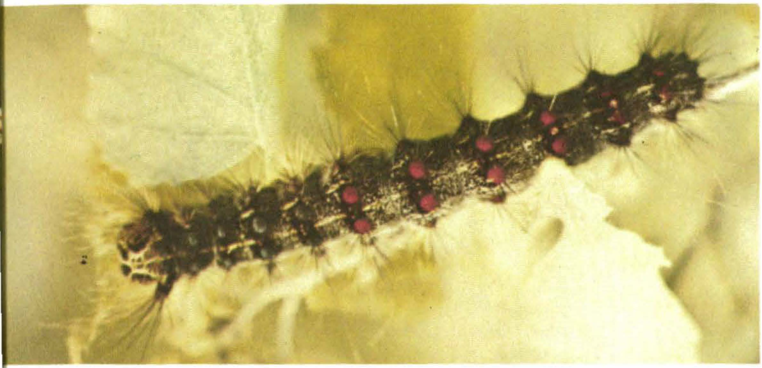
Larvae emerge in the spring and begin feeding immediately, sometimes utilizing expanding buds until foliage is available. The larvae do not form tents, but construct open silken mats on tree branches or trunks, where they congregate to rest and molt. The caterpillar matures in about 5 weeks, at which time it measures 2 to 2½ inches in length. The head is light blue with small, irregular black spots. Each body segment has a footprint-shaped white spot along the back. The sides of the body are pale blue-gray, bounded by a narrow orange stripe on the top and a white stripe below. The eggs, laid in mid-summer, are deposited in bands around small twigs on host trees. These bands are covered with a smooth, black, shiny substance. This pest has one generation per year.

GYPSY MOTH *Lymantria dispar*

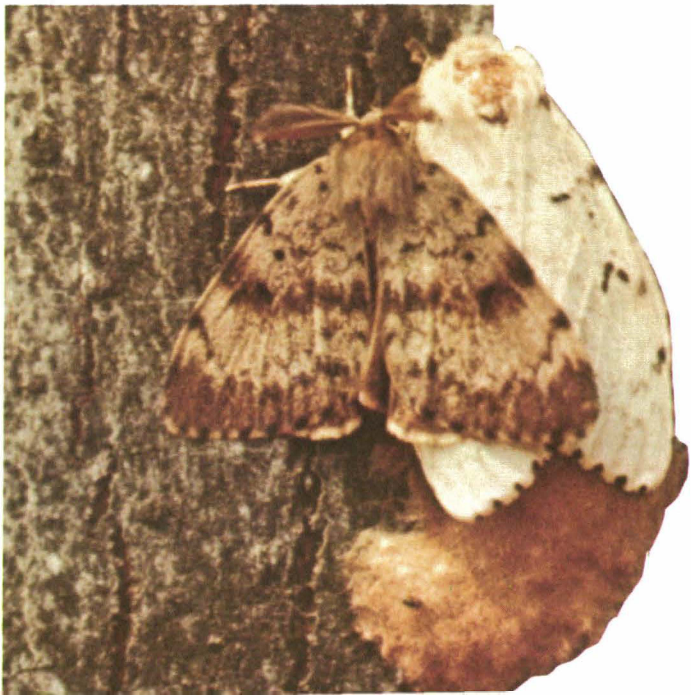
The gypsy moth is a defoliator primarily of hardwood trees, especially oak, although after the larvae are half-grown they will attack conifers. They usually do not infest ash, black walnut, catalpa, and yellow-poplar.

The range of this introduced pest is primarily the northeastern United States, from Maine south to New Jersey and west to western Pennsylvania. However, limited infestations have occurred in Lower Michigan and Wisconsin. Male moths have been reported as far west as Missouri.

The eggs hatch in late April or early May, with the larvae completing feeding in late June or early July. Older larvae may be recognized by the five pairs of blue spots and six pairs of red spots along the back. After feeding, the larvae pupate and emerge as adult moths in about 2 weeks. Shortly after the female emerges, she mates and begins laying eggs on trees, rocks, or other nearby objects. The female, too heavy with eggs to fly, deposits buff-colored masses of 100 to 1,000 eggs. The current year's egg masses can be found from late July or August until April or May of the following year. The gypsy moth has one generation per year.



Larva

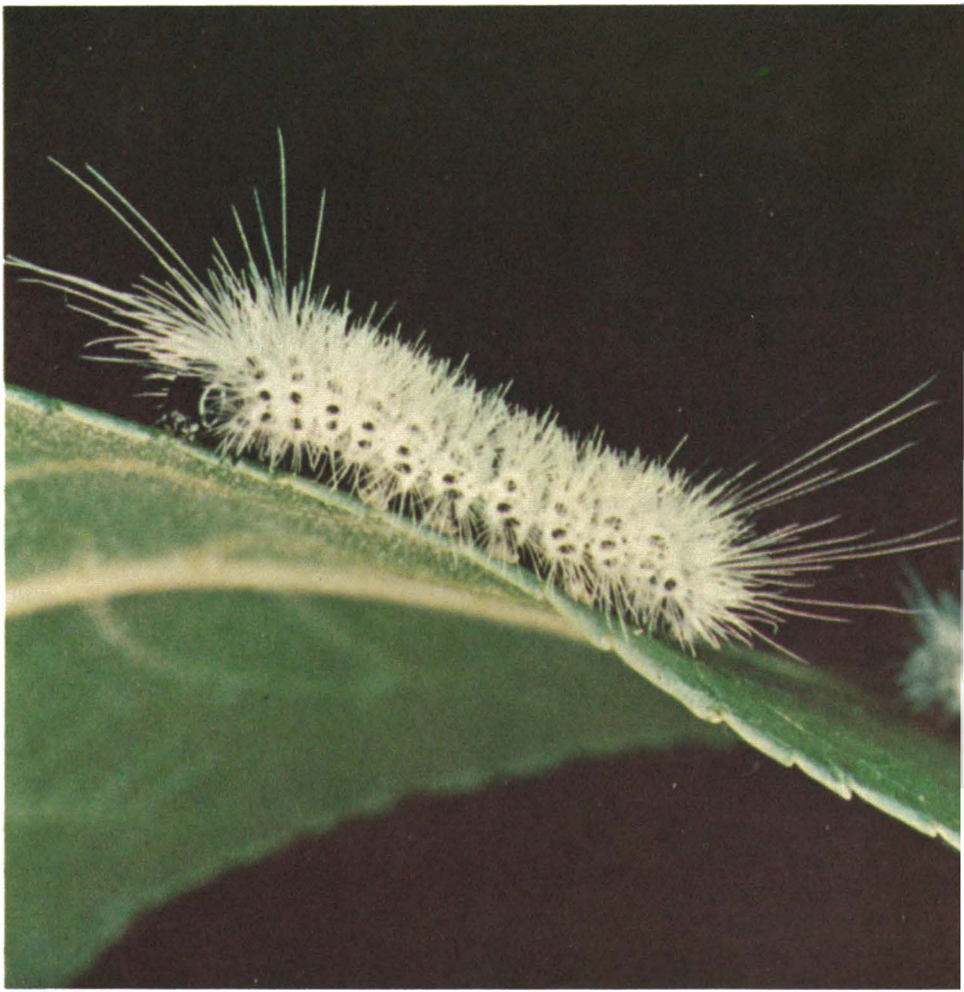


Gypsy moth — male, female, egg mass

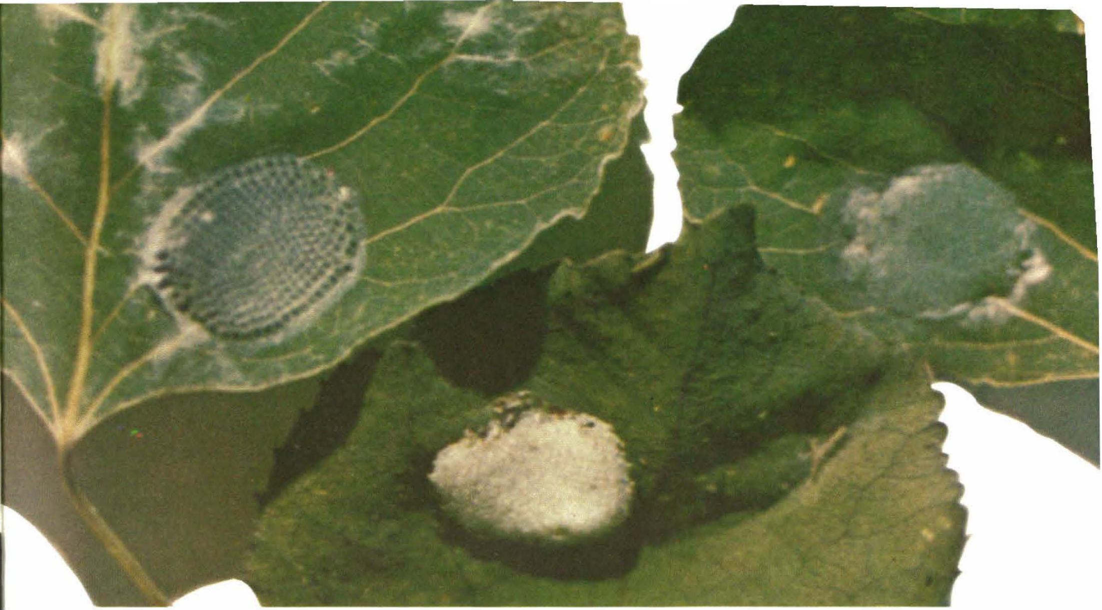
HICKORY TUSSOCK MOTH *Halisidota caryae*

The hickory tussock moth is an important defoliator of walnut, butternut, and hickory. It also feeds on birch, elm, black locust, basswood, and aspen.

Adults appear in late May to early June and deposit masses of 50 to 400 eggs on the undersides of leaves. In several weeks, the larvae emerge and begin feeding. The head of the caterpillar is black, and the body is covered with short tufts of grayish-white hair on the first and seventh abdominal segments. There is one generation per year, and the winter is spent in the pupal stage.



▲ **Larva**



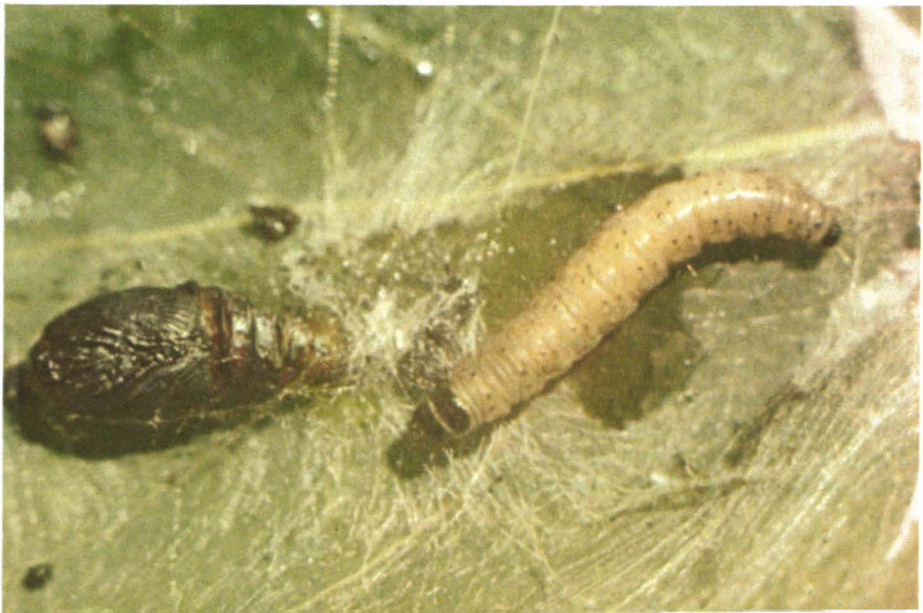
▲ Egg masses

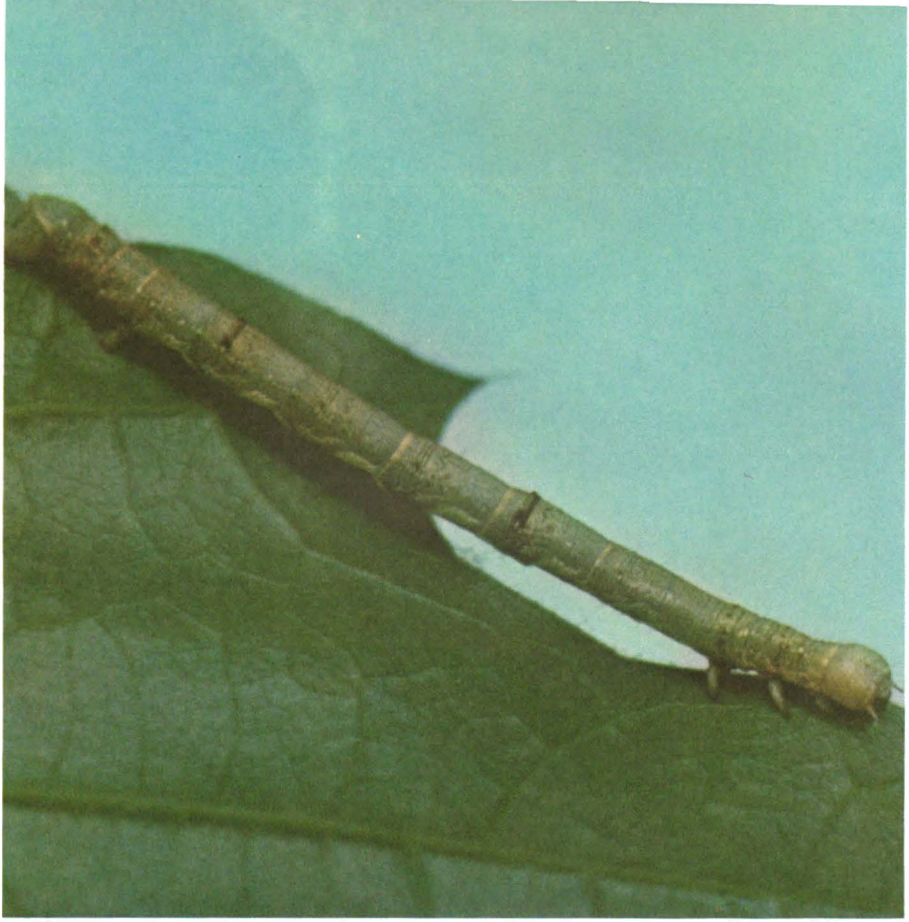
LARGE ASPEN TORTRIX *Choristoneura conflictana*

The large aspen tortrix is an early summer defoliator of quaking aspen. During epidemic outbreaks, it also feeds on balsam poplar, paper birch, willow, alder, and black cottonwood. Defoliated trees usually refoliate in mid- to late summer. Because new foliage is sparse and individual leaves are smaller, tree crowns appear thin.

The tortrix lays greenish, flat, overlapping eggs in round masses on upper leaf surfaces. The first-instar larvae spin hibernating cocoons in protected locations on the tree trunk, then molt and overwinter in the second larval stage. In the spring at about the time of bud break, larvae emerge, climb the tree and mine the expanding buds. The mature larva is green to black with a black head and anal plate. Pupation occurs in leaves rolled or webbed together on the tree. This pest has one generation per year.

▼ Pupa and larva





▲ Larva

ELM SPANWORM *Ennomos subsignarius*

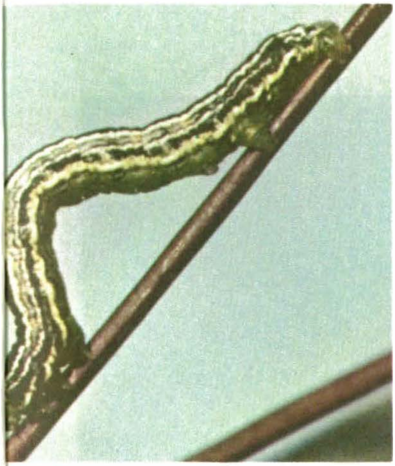
The elm spanworm periodically severely defoliates hardwoods throughout the eastern United States and Canada. Ash, hickory, and walnut are preferred, but elm, oak, cottonwood, and various other species are also heavily attacked. Yellow-poplar and sycamore are rarely attacked. Infestations may defoliate vast areas of mixed hardwoods in a relatively short time. Heaviest defoliation often occurs in mountainous terrain along ridgetops. Although one defoliation usually has little impact, two consecutive summers of defoliation can cause dieback and even mortality through invasion of secondary pests.

After overwintering, the eggs hatch in May or June, Initially, the larvae feed only on the lower surfaces of the leaves, producing a "shot hole" effect, but later they consume the entire leaf. During the early feeding period, they produce silky threads by which they often are wind-dispersed over large areas. The full-grown larvae are about 2 inches long. Color appears related to population density; in high populations, larvae are black with rust-colored head capsules; in low populations, they are green or yellow. Mature larvae construct silken cocoons among partly eaten leaves or in secluded areas such as bark crevices. In about 10 days, the new adults emerge and mate. The adult moth is white with a wingspan of about 1½ inches. Females lay eggs in compact groups on the undersurfaces of branches. There is one generation per year.

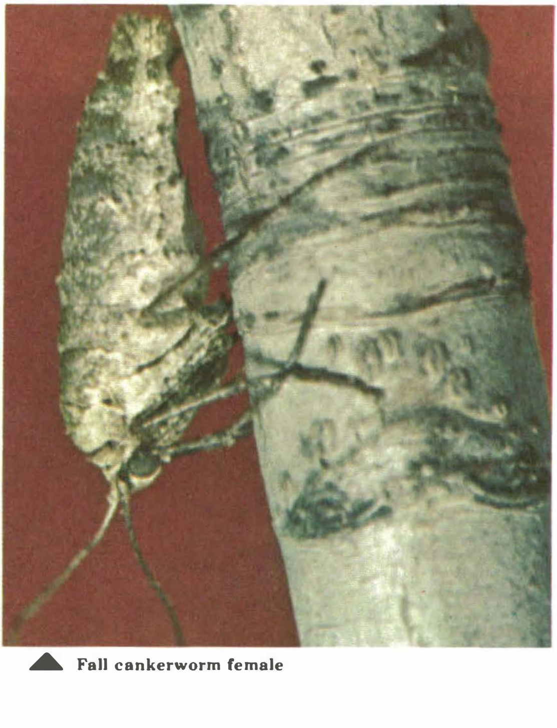
FALL CANKERWORM *Alsophila pometaria*
SPRING CANKERWORM *Paleacrita vernata*

Young larvae ("inchworms") of both these defoliators skeletonize new leaves of host trees. Older larvae consume entire leaves, leaving only the midribs. Tree mortality rarely occurs until after 3 years of heavy defoliation. Infestations are generally short-lived, lasting 2 to 3 years. Preferred hosts appear to be apple and elm, but stands of hickory, maple, ash, yellow birch, beech, basswood, boxelder, cherry, and oak have also been severely defoliated.

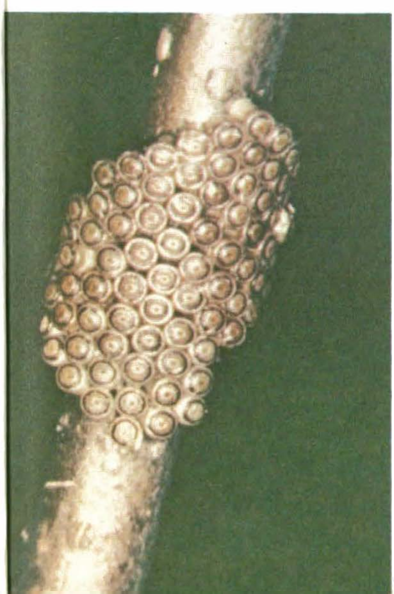
Full-grown fall cankerworm larvae have three pairs of false legs on the abdomen, vary from light green to dark brownish green, and are about 1 inch long. Spring cankerwom larvae have two pairs of false legs on the abdomen, are reddish to yellowish brown, yellowish green, or black, and are ¾ to 1¼ inches long. The life cycles of both pests are similar except for the overwintering stages; fall cankerworms overwinter as adults and eggs, while spring cankerworms overwinter as pupae. There is one generation per year in each species.



▲ Fall cankerworm larva



▲ Fall cankerworm female

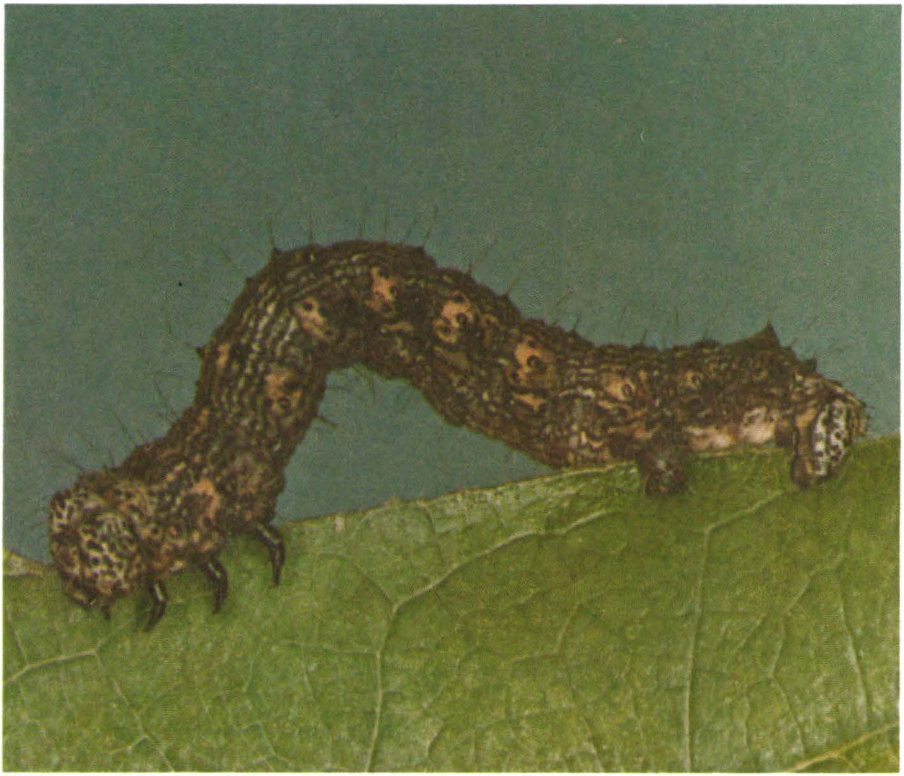


◀ Fall cankerworm egg mass

HALF-WING GEOMETER *Phigalia titea*

This looper feeds on many hardwood species, but favors red oak, red maple, basswood, hickory, and elm. Tree mortality generally is confined to individuals weakened by drought, disease, or other stress conditions.

After overwintering as pupae, adults emerge in April and quickly mate. Wingspan of the male moths averages about 1½ inches. Forewings are grayish and marked with specks, dark lines, and spots along the edges. Although winged, females cannot fly. Females deposit eggs in inconspicuous sites on the bark. After 2 or 3 weeks, the eggs hatch and young larvae begin to skeletonize leaves. Later they consume entire leaves except for the major veins. Mature larvae are about 1½ inches long, gray to brown, with numerous black lines running the length of the body, yellow patches on the sides, and many sparse hairs and small black projections on the body segments. Some dispersal occurs when larvae spin silken threads and are carried by the wind to other locations. Pupation takes place in the soil litter. There is one generation per year.

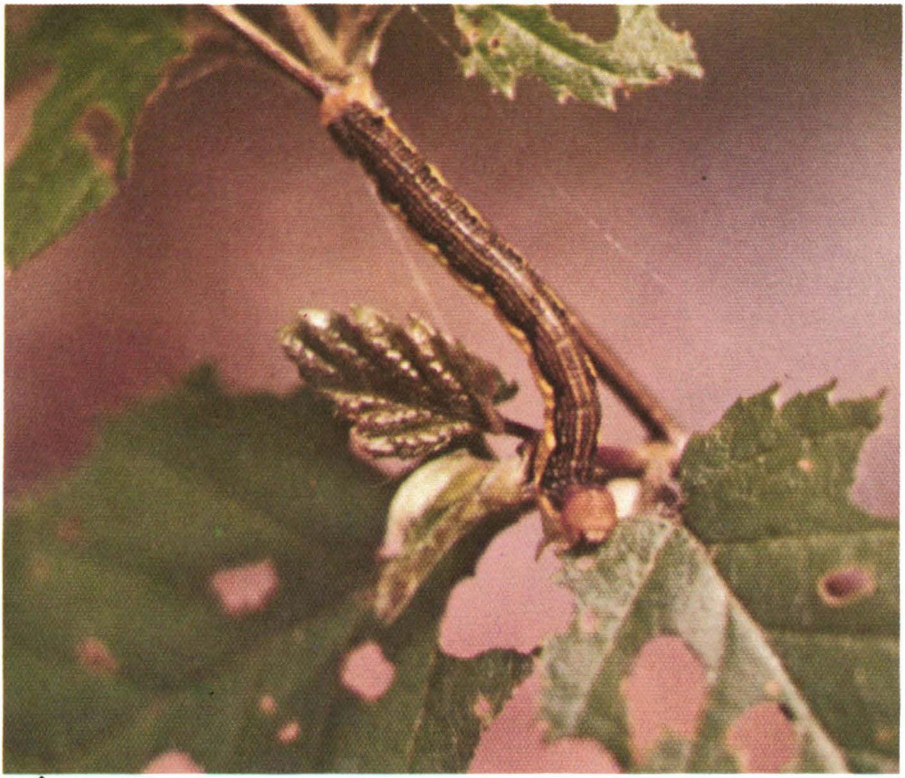


▲ **Larva**

LINDEN LOOPER *Erannis tiliaria*

The linden looper defoliates many tree species, including basswood, elm, maple, hickory, oak, and birch. Although affected stands usually recover, repeated defoliations can contribute to tree mortality. Under outbreak conditions, this looper is frequently found in association with the fall cankerworm. Parasitic flies and viral epizootics contribute to the collapse of some outbreaks.

Overwintering eggs hatch in late April or May. Larvae feed voraciously until late June, then pupate in soil cells for about 3 months. Full-grown larvae are yellow with light-brown head capsules. Undulating black lines run the length of the dorsal surface. When mature, larvae average 1½ inches in length. Adult females are wingless, gray to brown, and about ½ inch long. Forewings of the male moths are brownish and marked with transverse bands and dots. Wingspan averages 1½ inches. In the fall, females mate and deposit individual eggs or small groups of eggs in bark crevices. There is one generation annually.

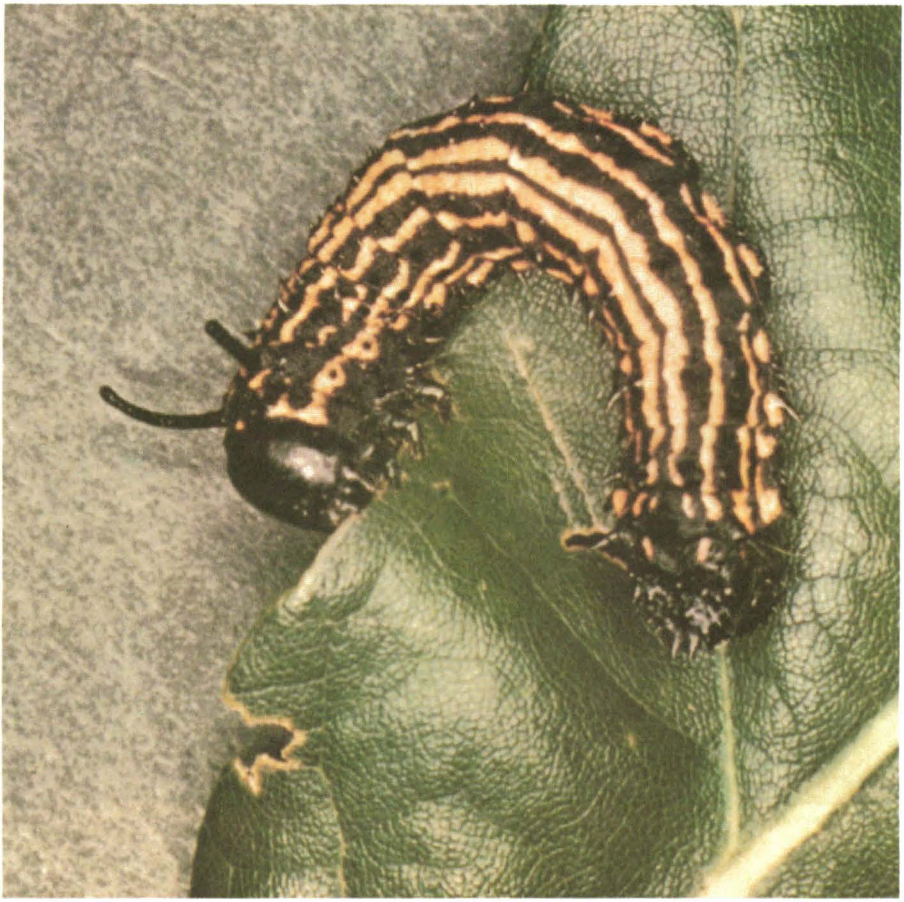


▲ **Larva**

ORANGESTRIPED OAKWORM *Anisota senatoria*

This insect defoliates oaks in late summer. Although repeated defoliation may weaken the trees, the greatest damage is the esthetic impact and the nuisance the caterpillars create. Severe infestations rarely last more than 1 or 2 years.

Adults emerge from the soil in June and July, mate, and lay eggs in large clusters on the undersides of oak leaves. The eggs hatch in about a week, and the caterpillars begin to feed on leaf tissue, leaving only the ribs. The colonies break up early, and caterpillars scatter throughout the tree. Full-grown caterpillars are black and about 2 inches long, with eight yellow-orange stripes running the length of the body. The head is black and shiny. Two long, recurving spines are located behind the head; each body segment bears a shorter pair of spines. The oakworms mature in September or October, drop to the ground, and dig into the soil 3 to 4 inches, where they pupate. After overwintering as pupae, the adults emerge in June. There are sometimes two generations per year, depending on location.

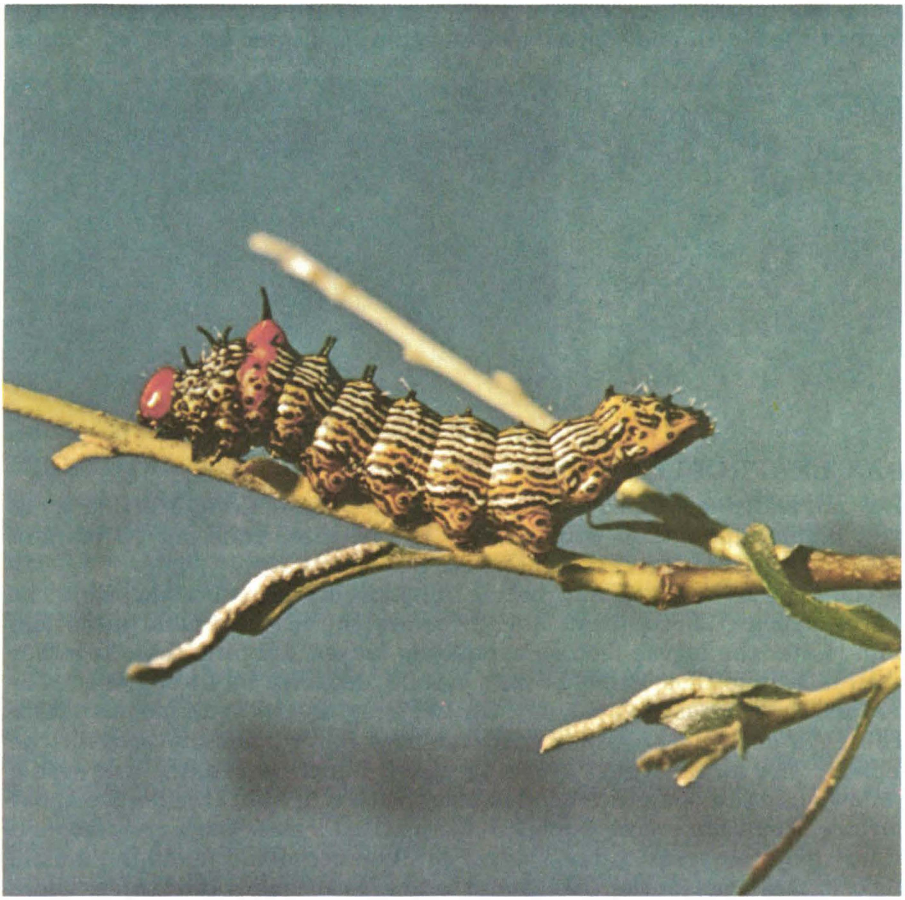


▲ **Larva**

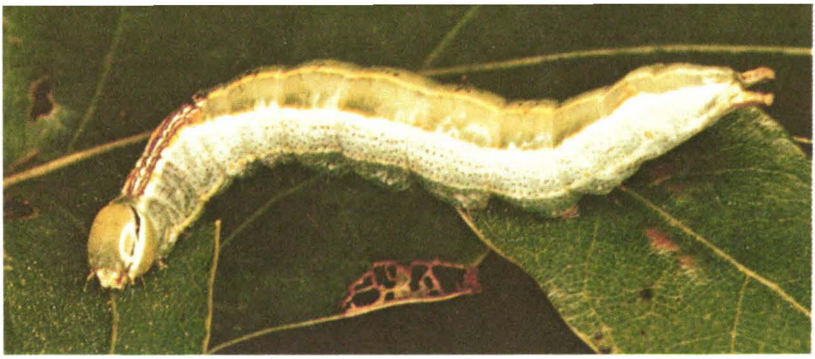
REDHUMPED OAKWORM *Symmerista canicosta*

Defoliation by the redhumped oakworm becomes noticeable in oak stands in late summer. This insect attacks all oak species, but outbreaks tend to develop in areas where the white oak group predominates. No permanent tree damage results from a single, complete defoliation. The greatest problem is the nuisance the larvae create — frass dirties camping, picnicking, and residential areas and migrating larvae become odorous when they die from lack of food.

Adult females lay eggs in June and July in batches of about 50 on the undersides of leaves. The eggs hatch in 10 days, and the caterpillars feed in colonies on the upper surfaces of leaves, consuming more leaf tissue as they grow. When the caterpillars are about an inch long, the colonies begin to break up. The full-grown larva has a rounded orange-red head and yellowish body with fine, black lines extending its full length. On top of the body near the tail is an orange-red hump. Mature caterpillars drop to the ground in late September and pupate between rolled leaves in the litter. Some may overwinter as prepupal larvae. Adult moths emerge in June. There is one generation per year.



▲ **Larva**

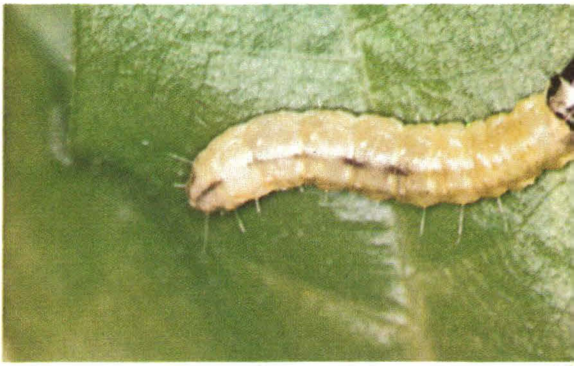


◀ Larva

VARIABLE OAKLEAF CATERPILLAR *Heterocampa manteo*

The variable oakleaf caterpillar occasionally defoliates extensive areas of hardwood forests. This insect prefers oak trees, but also will feed on beech, basswood, birch, and various other hardwoods.

The larvae overwinter in earthen cells in the topsoil. Pupation occurs in early spring, and the adults appear in May or early June. Eggs are deposited singly on the leaves; each female is capable of laying up to 500 eggs. The larvae feed for 5 to 6 weeks, then drop to the ground to form their larval cells. The larvae vary in color, but at maturity are usually yellow-green with a broad, dark band down the back. The head is usually rust-colored with two lateral, curved bands (outer one creamy white and inner one black) on each side of the head. There is one generation per year in the North and sometimes two generations per year in the South.

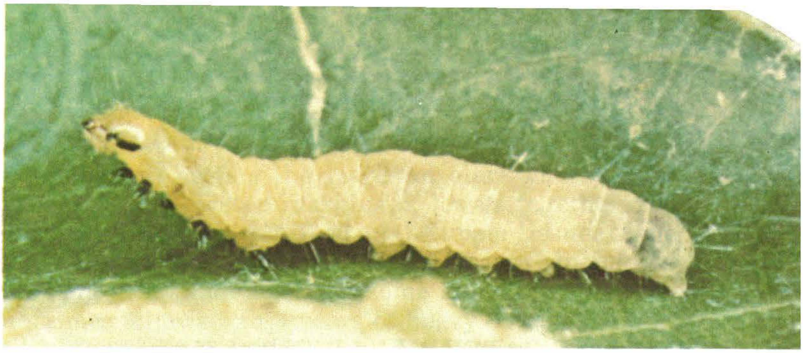


▲ Larva

OAK LEAFROLLER *Archips semiferanus*

The oak leafroller is an important bud miner and defoliator primarily of oak, maple, apple, and witch hazel. Two or three consecutive years of heavy defoliation can cause extensive tree mortality.

The eggs overwinter and hatch in spring at or before the time the leaves appear. Larvae that emerge before the leaves unfold mine leaf buds. Later the larvae feed on expanding leaves, webbing them together until late June. The leafroller may best be identified by its egg masses or larvae. The masses are oval, flat, whitish gray, and 3⁄16 of an inch in width. The eggs are held together with compact hairs from the body of the female. The larva, which grows to about 1 inch in length, has a pale yellowish-green body. The head is black with a lighter area on the upper surface. Pupation occurs during July in rolled leaves, bark crevices, and other sheltered areas. After a week, adults emerge and mate; the female deposits her eggs on the trunks and lateral branches of host trees. There is one generation per year.

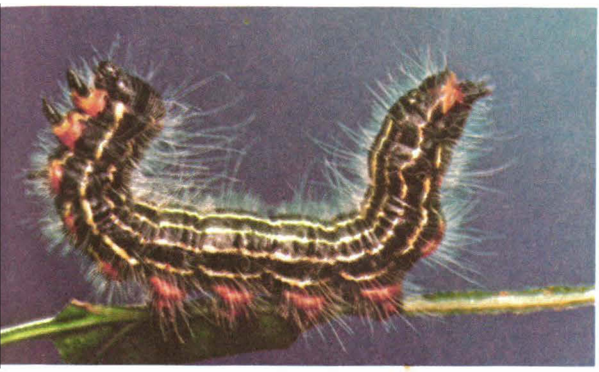


▲ Larva

OAK LEAFTIER *Croesia semipurpurana*

The oak leaftier is a bud miner and defoliator that causes considerable tree mortality in the Appalachian region. Various oak species are attacked, but those in the red oak group seem to be most susceptible.

The eggs overwinter on oak branches and hatch in the spring. Young larvae burrow into expanding buds, while older larvae tie sections of leaves together and feed inside the folds. The full-grown larvae are dirty white to light green. The pale head capsule has black bars on the sides. Usually in May the mature larvae spin down to the ground and pupate in the soil litter. Pupation lasts from 1 to 2 weeks. Adults emerge and mate, and eggs are deposited individually on the bark of second-year branches. Only one generation per year has been reported.



◀ Larva

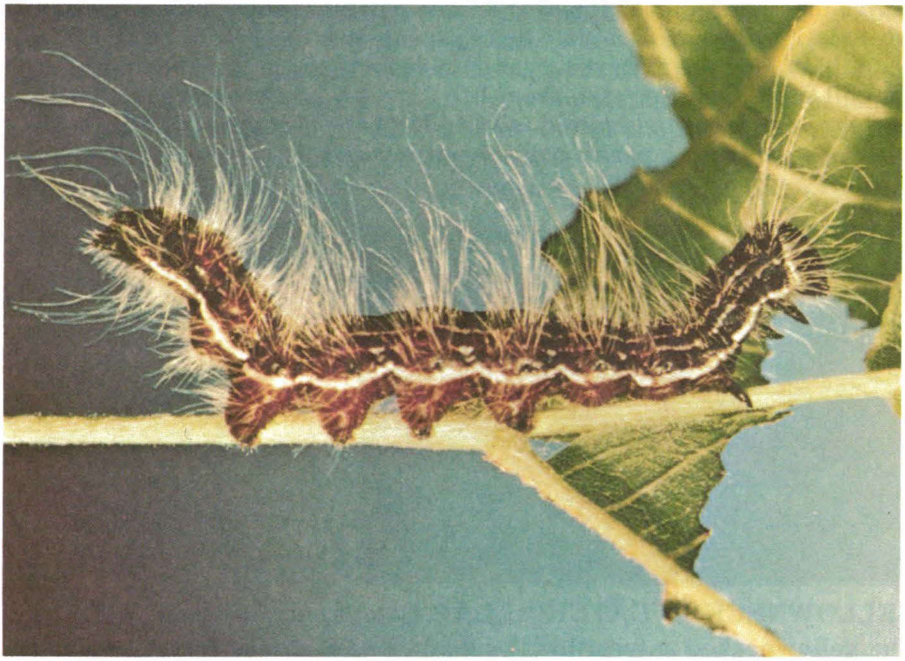
YELLOWNECKED CATERPILLAR *Datana ministra*

The yellownecked caterpillar is seldom a widespread forest pest, but heavily infested trees may be defoliated completely by mid- to late summer. Defoliation appears first on the periphery of the tree crown. The preferred hosts are white and yellow birch, basswood, elm, oak, maple, butternut, walnut, mountain-ash, eastern hophornbeam, and honey locust.

In June and July, females lay eggs in masses of 100 or more on the undersides of the host leaves. A newly hatched larva has a black head and a reddish body with narrow, yellow stripes. Larvae feed in colonies on foliage at branch ends. When disturbed, larvae raise both ends of their bodies. Mature larvae are black with four narrow, yellow stripes running the length of the body. The neck is circled by a narrow, yellow band. Moderately dense, long, white hairs cover the body. When mature, larvae drop to the ground, where they pupate and overwinter in the soil. There is one generation per year.

WALNUT CATERPILLAR *Datana integerrima*

The walnut caterpillar feeds on the foliage of walnut, butternut, pecan, hickory, and several other species. The larvae feed in colonies, usually eating the foliage on one branch before moving to another. The first-instar larvae are skeletonizers, whereas older caterpillars consume the entire leaf.



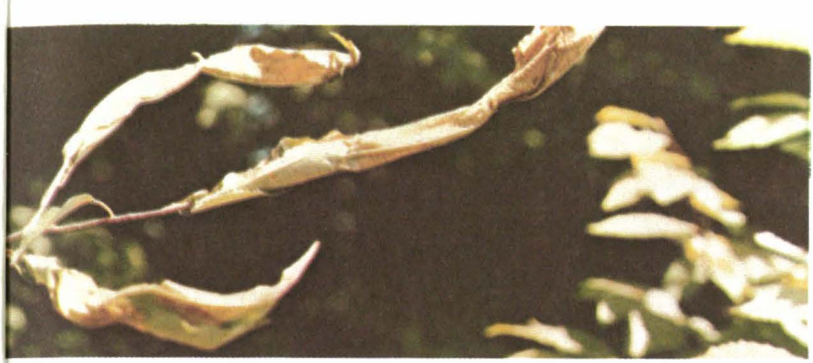
▲ **Larva**

The eggs are deposited in masses of 300 or more on the undersides of leaves in early June. The half-grown larvae take on a brick-red color; later, they turn grayish black with yellowish longitudinal stripes and long, grayish white hairs. The caterpillars, when disturbed, arch their heads and tails in an attempt to discourage predators. The larvae molt together, leaving behind a clump of dirty-white cast skins. The walnut caterpillar has one generation in the northeastern states and two generations in some of the southern states.

CHERRY SCALLOP SHELL MOTH *Hydria prunivorata*

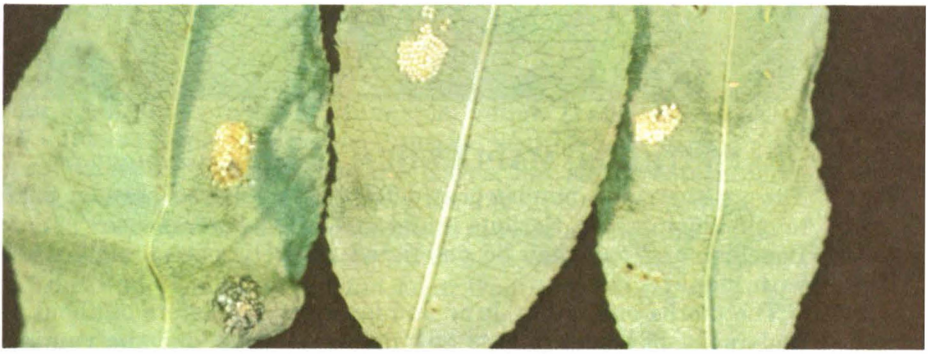
The cherry scallop shell moth prefers the leaves of black cherry, wild cherry, and chokecherry. Larvae fasten margins of leaves together and form an elongated nest, within which they feed on the upper tissues of the leaves. Progressive feeding usually defoliates entire trees, reducing radial growth the following year and subjecting some stands to rapid decline. Mortality sometimes follows 2 to 3 years of heavy defoliation.

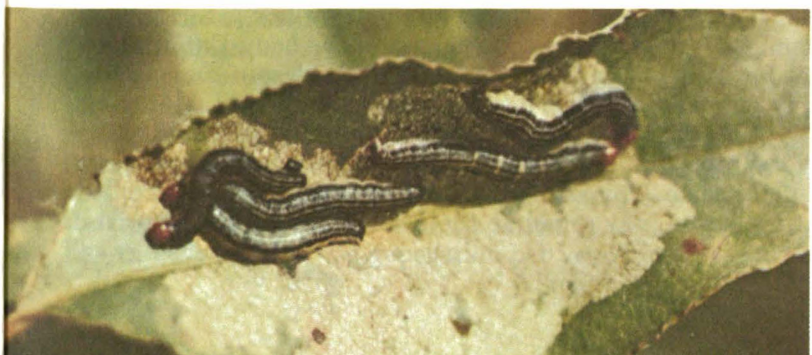
The winter is spent as a pupa in leaf litter or in the upper soil layer. Adults emerge in late spring or early summer. Females lay eggs during late June in pyramid-shaped masses, one to four layers deep, on the undersides of leaves. Egg laying continues throughout the summer. Eggs hatch in a few days, and larvae are present through early fall. Grown larvae are pale yellow with dark-gray or black dorsal stripes; the head is usually orange-brown. There is one generation per year in the northern part of the range.



◀ **Damaged leaves**

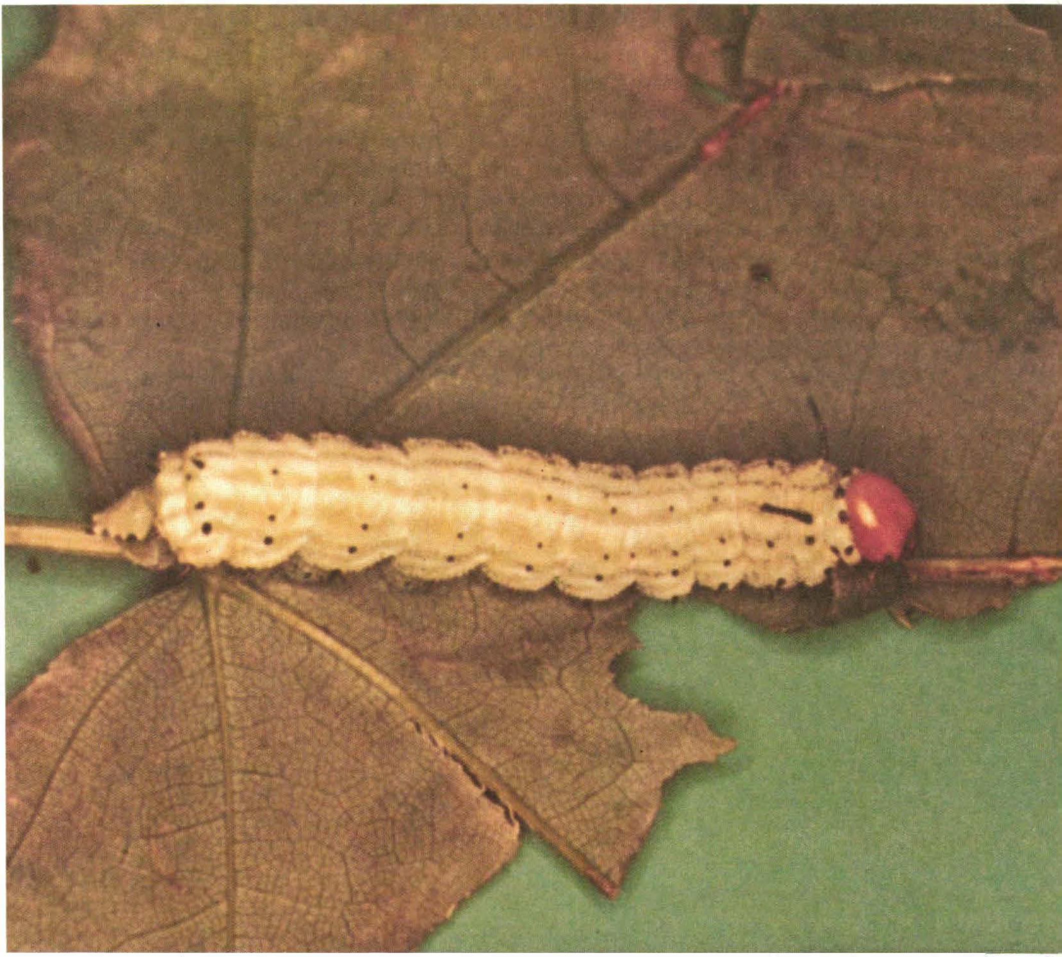
Egg masses ▶





◀ **Larvae**

Photo credit: Douglas Allen, N.Y. State College of Env. Science and Forestry

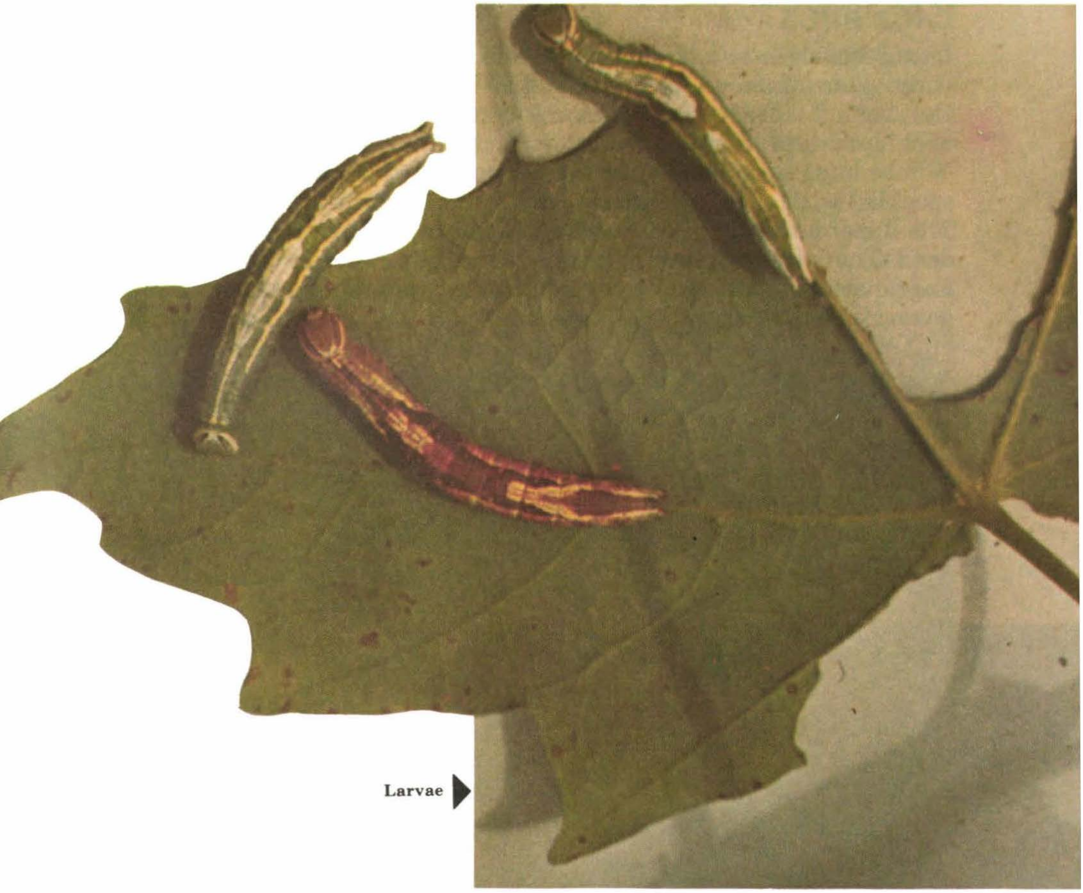


▲ Larva

GREENSTRIPED MAPLEWORM *Dryocampa rubicunda*

The greenstriped mapleworm defoliates hardwood stands, particularly maple, during July. Serious injury can follow several years of defoliation. Boxelder and oak may be defoliated severely, particularly when mixed with maple.

The moths emerge in June and lay eggs in clusters of about 40 on the undersides of leaves. The eggs hatch in 10 days, and the young caterpillars begin feeding on the leaves and scatter early. Full-grown caterpillars, about 1½ inches long, have reddish heads and pale yellow-green bodies; seven dark green or black stripes run the length of the body. Caterpillars have prominent horns near the head, two rows of short spines along the side of each body segment, and four larger spines near the tail. Maturing in about 4 weeks, they drop to the ground and form pupal cells in the soil, where they overwinter. Some adults emerge in late summer and may start a second generation. This is more common in the South, where the second generation larvae may complete their development and overwinter as pupae.



Larvae ▶

SADDLED PROMINENT *Heterocampa guttivitta*

The saddled prominent prefers sugar maple, yellow birch, paper birch, and beech, but also feeds on other tree species such as oak, aspen, and apple. Young caterpillars skeletonize the leaves, but as the caterpillars mature they consume entire leaves except for a few principal veins. Two or three successive years of severe defoliation may cause significant tree mortality in yellow birch. During droughts or on poor sites, trees of other species may die, and yields of syrup and sugar from sugar maples may be reduced.

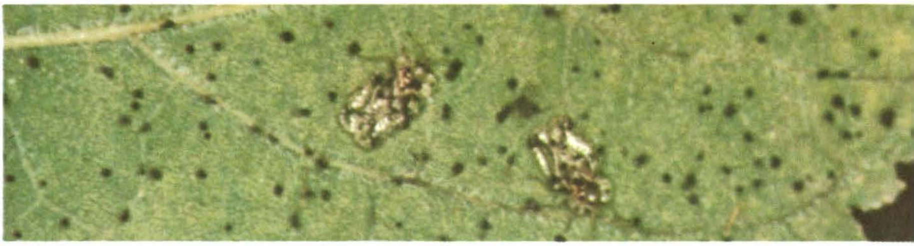
The brownish gray moths emerge in late May and early June. The moths — which have a wingspan of about 2 inches — have indistinct and variable crossmarkings on the forewings. Each female moth lays up to 500 pale-green eggs, depositing them singly on the undersides of leaves. Dark-green caterpillars emerge from the eggs in 8 to 14 days. As the caterpillars grow larger, their bodies become light green with reddish to purple saddle-like markings in the middle of the back. When fully grown, caterpillars are about 1½ inches long. Pupae are a glistening dark brown, about ¾ of an inch long, and usually enclosed in a loose silken cocoon in the leaf mold of the forest floor. Pupation occurs in late July and August. The insect produces one generation per year.

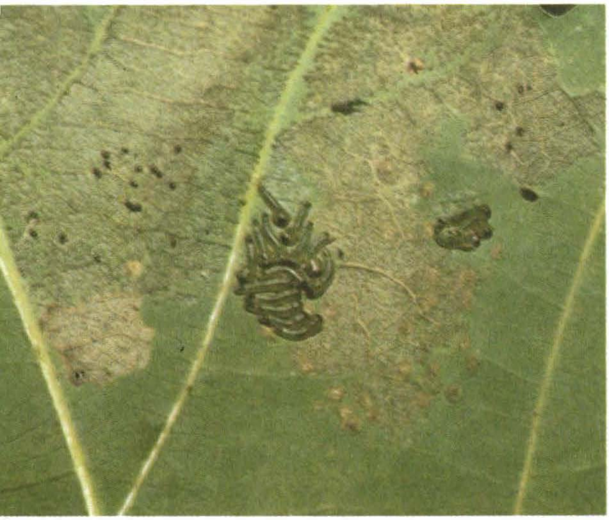
LACE BUGS *Corythucha* spp.

Lace bugs are whitish sucking insects with broad gauze-like or lace-like wing covers. Various species attack a number of trees and shrubs; species that attack forest trees include sycamore, oak, basswood, elm, and hackberry lace bugs.

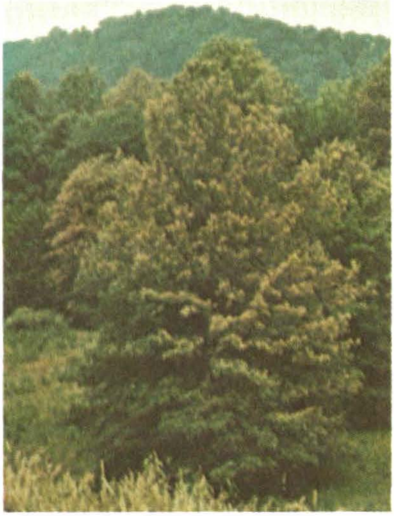
Lace bugs live and feed on the undersides of leaves, often leaving them speckled with eggs, excrement, and the cast skins of developing nymphs. The upper surfaces of infested leaves may appear whitened, brownish, or dead. The leaves of heavily infested trees often turn brown and fall. Lace bugs overwinter in either the adult or egg stage. Most species have two generations per year.

▼ **Lace bugs**





▲ **Larvae**



▲ **Defoliated trees**

PIN OAK SAWFLY *Caliroa lineata*

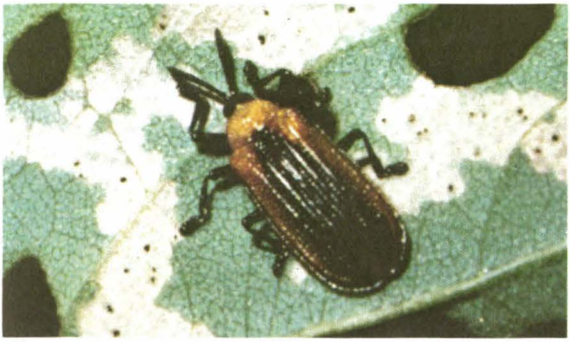
The pin oak sawfly feeds on the lower surface of oak leaves, leaving only the upper surface and a fine network of veins. Defoliation first appears in the upper tree crown, but complete defoliation can occur by the end of September. The preferred host is pin oak, but other red oaks and white oak may be affected.

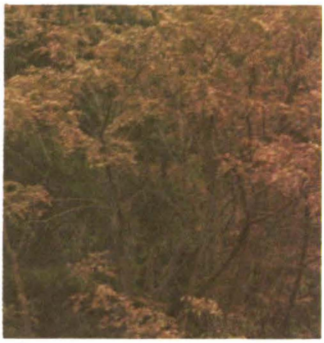
Adults are small, shiny-black, four-winged insects. The yellowish-green larvae or slugs are about ½ inch long. The thoracic legs and head are shiny black. Larvae and adults may be found almost anytime between May and September. Two generations per year are produced as far north as New Jersey.

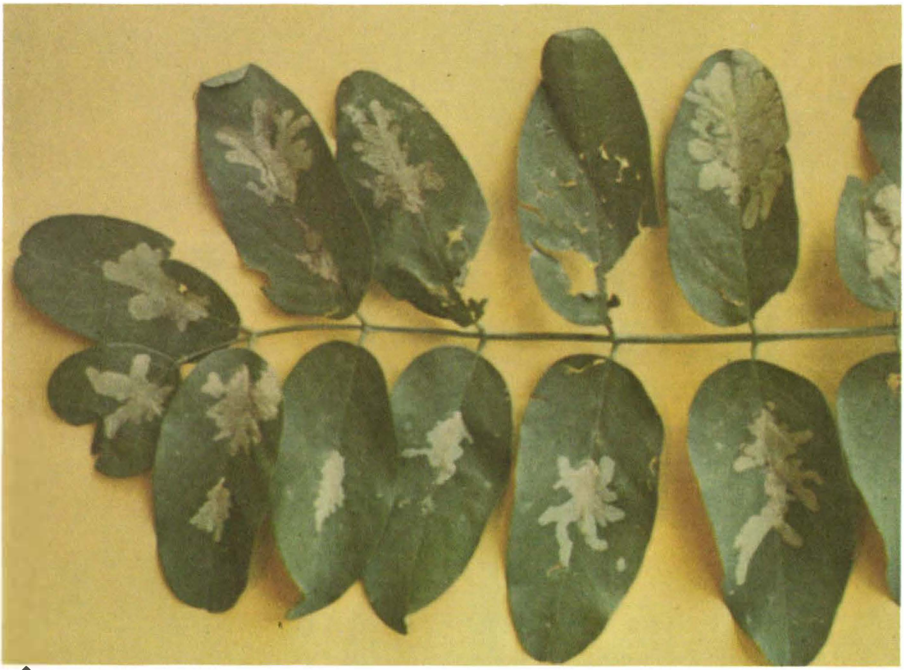
LOCUST LEAFMINER *Odontota dorsalis*

The locust leafminer prefers the leaves of black locust, but will attack apple, birch, wild cherry, elm, and oak. The emerging adults skeletonize and eat holes in the unfolding leaves. The larvae mine the tissue between the leaf surfaces, causing damage ranging from light-brown leaf patches to general defoliation. Although extensive stands are sometimes defoliated, the trees are seldom killed.

The adult is an elongate, flat-bodied beetle with a black head and thorax and bright orange wingcovers. Adults overwinter in bark crevices or under soil debris, emerge in the spring, and feed for a short period. Females lay eggs in groups of three to five on the lower surfaces of leaves. Young larvae bore into the leaf and feed in a common mine, while full-grown larvae separate and mine individually. Mature larvae are yellowish-white, flattened, and about ¼ of an inch in length. Pupation occurs in the larval mines. There is only one generation per year.


▲ Adult

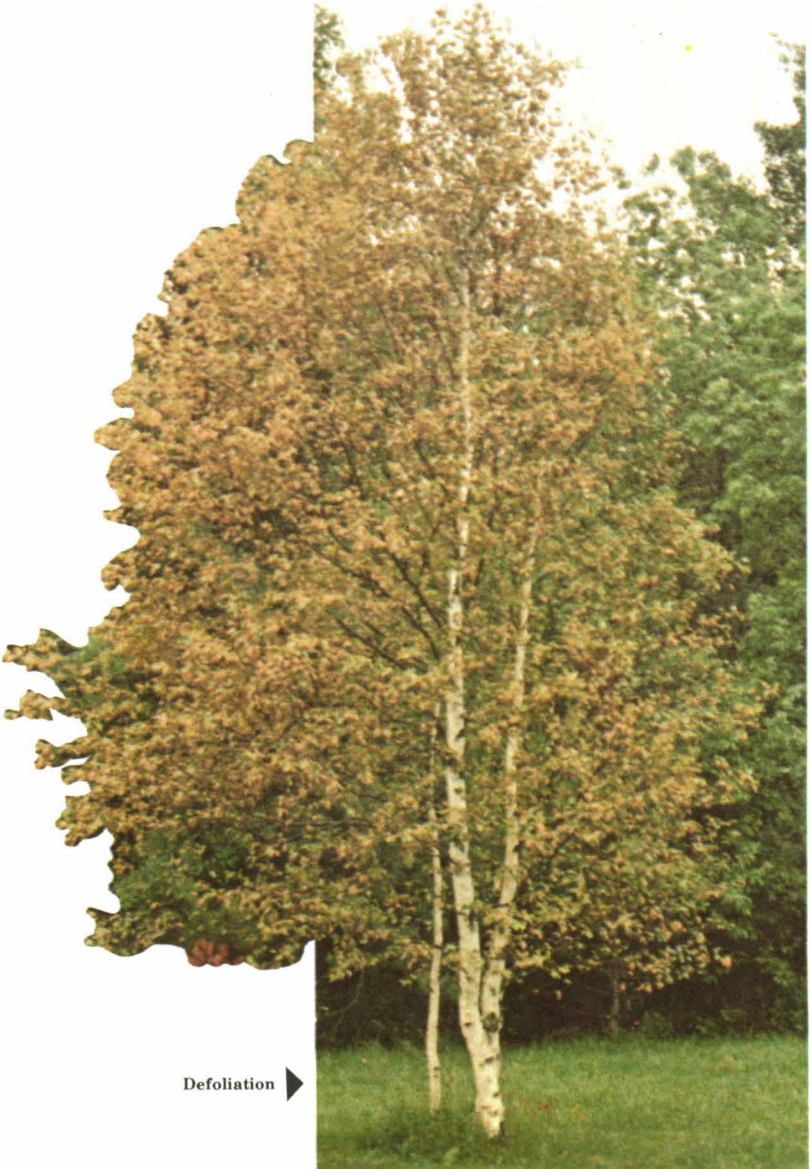

▲ Defoliation


▲ Larval mines

BIRCH LEAFMINER *Fenusa pusilla*

This introduced sawfly attacks all species of birch, but gray birch and paper birch are most susceptible. Defoliation by the birch leafminer is unsightly and may predispose trees to attack by the bronze birch borer. Defoliation also permits excess heating of the soil by direct sunshine. The resulting high temperatures can kill roots and lead to birch dieback.

The flattened, yellowish-white larvae are about ¼ of an inch long with black spots on the underside of the thorax and on the first abdominal segment. Larvae feed on tissue between the leaf surfaces, creating irregular, brown, dry patches on the leaves. Full-grown larvae chew exit holes in the leaves and then drop to the ground, where they hibernate in the soil. Pupation occurs during April. First generation adults emerge in early May. There may be three or four generations per year.

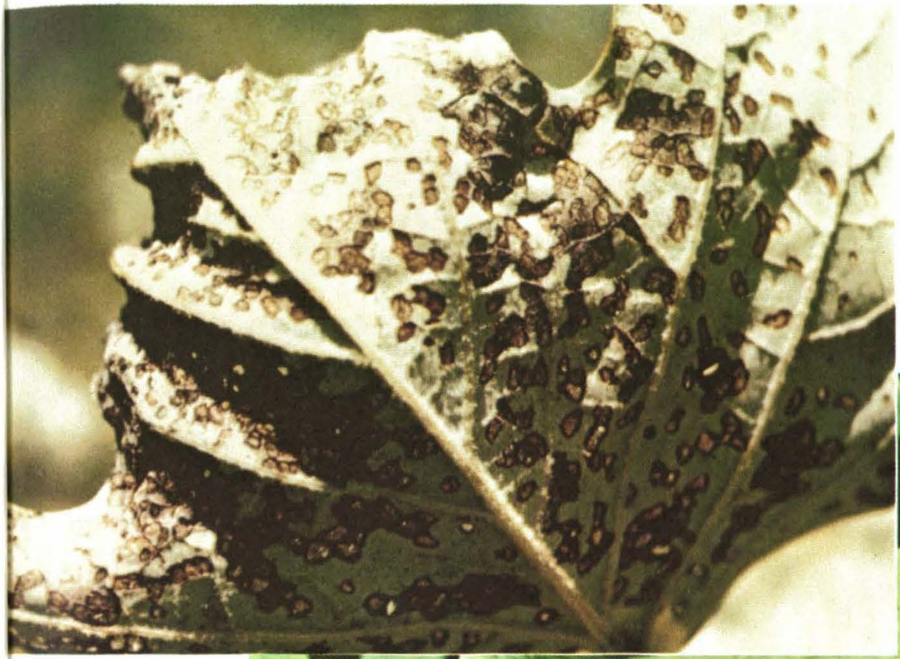


Defoliation ▶

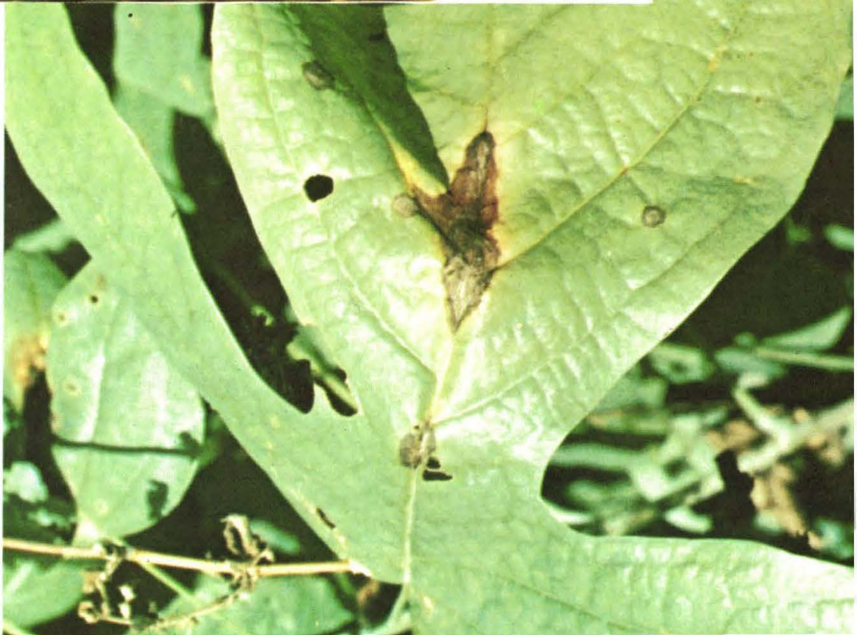
YELLOW-POPLAR WEEVIL *Odontopus calceatus*

Adults and larvae of the yellow-poplar weevil damage buds and leaves of yellow-poplar, magnolia, and sassafras.

Adults feed on expanding buds in April and May and later feed on the leaves, making rice-shaped holes. Eggs are deposited in the midribs of the undersides of leaves during May and early June. The larvae mine the leaves and later pupate within the mines. The adults then emerge and feed on the leaves until about mid-July, when they enter the duff and hibernate until the following spring. There is one generation per year.



Adult feeding

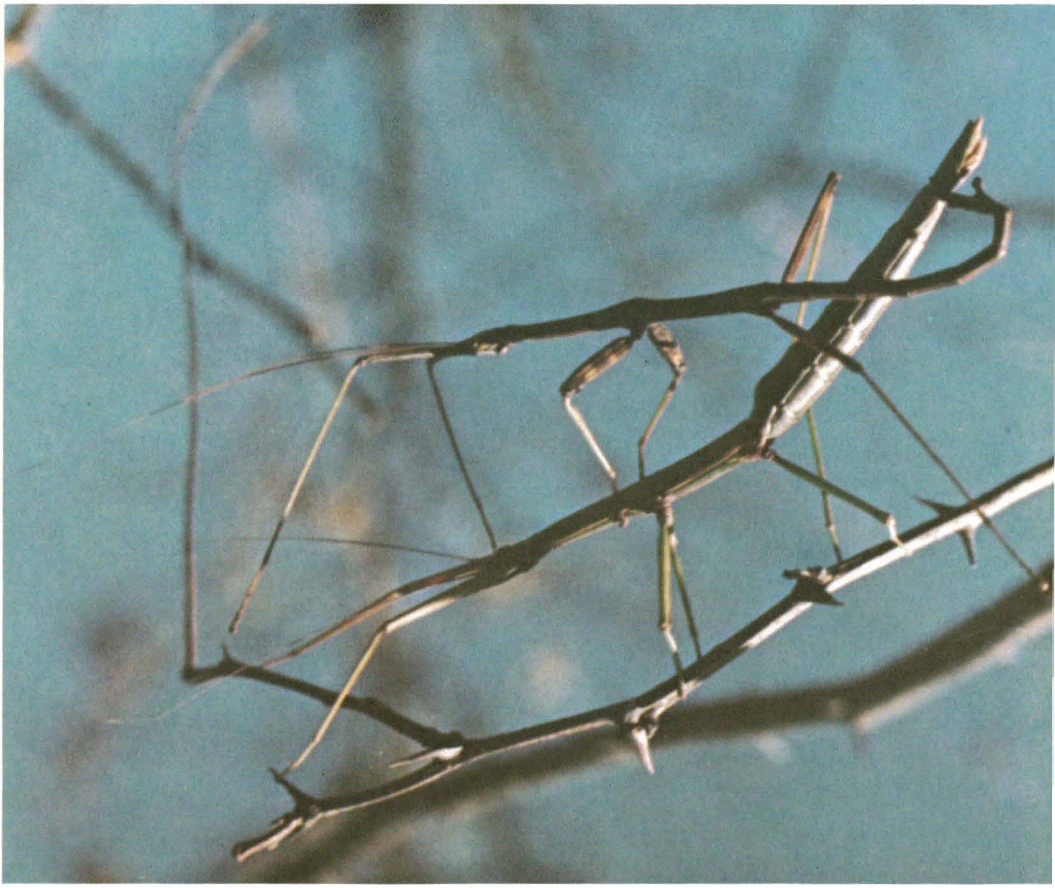


Early larval mines ▶

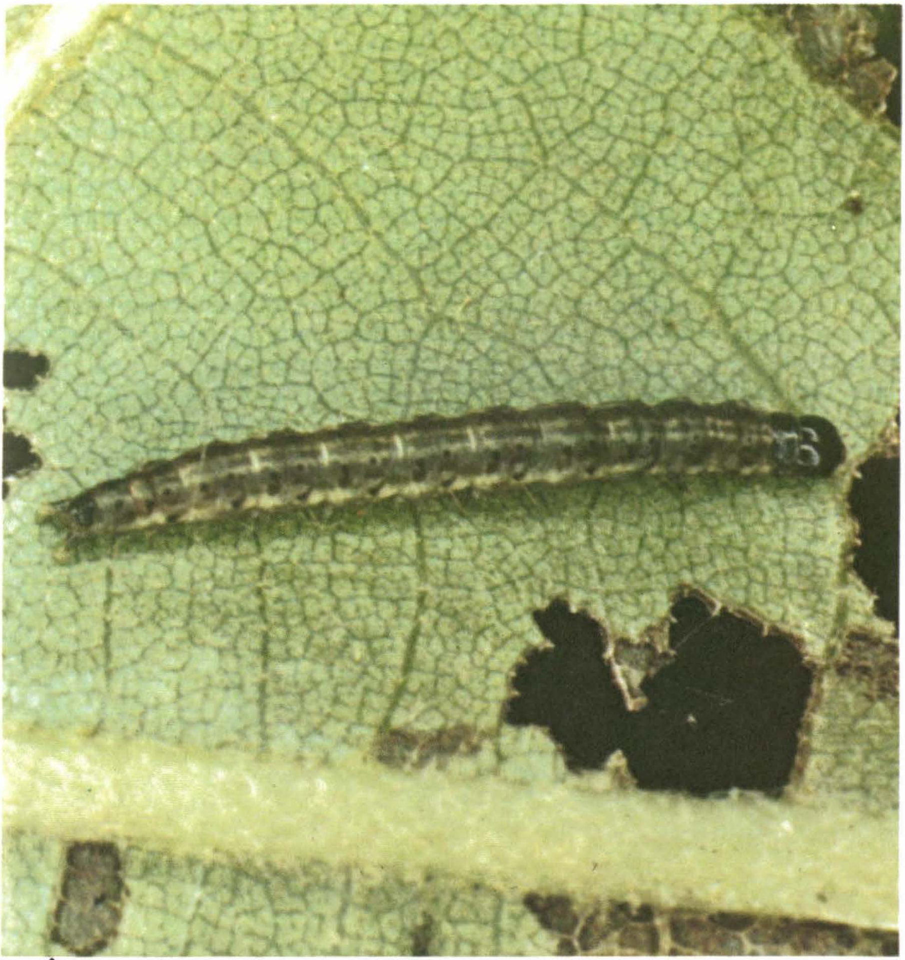
WALKINGSTICK *Diapheromera femorata*

The walkingstick, a defoliator of broad-leaved trees, consumes the leaf blade, leaving only parts of stout veins. Defoliation sometimes occurs twice in one season, and an extensive outbreak can defoliate a large area. Three to four heavy defoliations may kill branches. Infestations are localized because walkingsticks are wingless. Preferred hosts include black oak, basswood, elm, black locust, and wild cherry. Walkingsticks also feed on white oak, aspen, paper birch, ash, dogwood, and hickory.

Adults are slender, twig-like insects, pale green when young, gradually changing to various colors of dark green, gray, or brown at maturity. They are approximately 3 inches long. They mate late in July or mid-August, and females lay eggs about a week later. The hard-shelled, seedlike eggs are dropped to the ground where they overwinter. Egg laying continues until the onset of cold weather. In the North, eggs hatch during the second spring following deposition, usually in May or early June. In the South, most eggs hatch the following spring. Nymphs, resembling miniature adults, feed on sweetfern, blueberry, strawberry, and juneberry until midsummer, then move to host trees to feed. Two years are generally required for development of this insect, and there are even-year and odd-year broods in various parts of the Northeast.



▲ **Adults**



▲ Larva

PALMERWORM *Dichomeris ligulella*

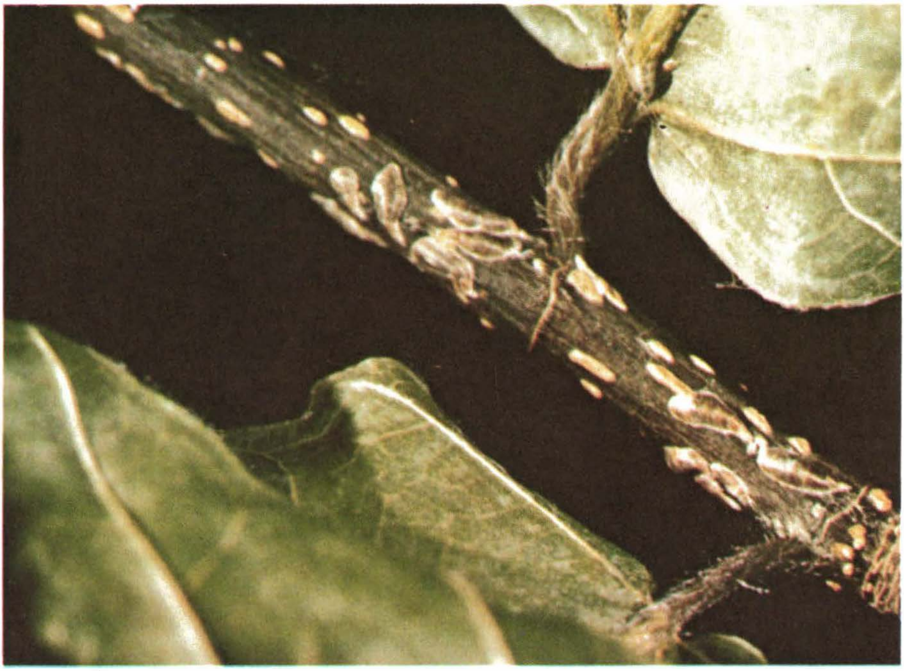
The palmerworm is occasionally responsible for widespread defoliation of hardwoods such as red, white, and chestnut oaks, basswood, cherry, and apple. The larvae skeletonize leaves and may fold or roll them during feeding. Outbreaks rarely last more than 1 or 2 years, and usually occur during unusually hot, dry springs. Although they may cause noticeable defoliation, outbreaks rarely result in permanent tree damage.

Adult moths overwinter and in spring the females lay eggs, depositing them singly on the expanding leaves. Larval feeding peaks during June; the full-grown larvae are about ½ inch long and can be identified most easily by the one narrow and two wide green stripes running down the back. Pupation takes place early in July at the final feeding site, and most adults appear by the end of July. The grayish to brownish adult moths are about ⅔ inch long, and are most conspicuous during outbreaks when large numbers are disturbed from resting sites on shrubs and small trees. There is one generation annually.

OYSTERSHELL SCALE *Lepidosaphes ulmi*

Oystershell scale insects feed on many species of deciduous trees by sucking sap from the twigs. Damage is usually light, but some species, particularly ash, can die if infestations persist. Dead and dying branches and abnormally small or discolored leaves are the first indications of this scale. Close examination of the twigs reveals a flattened, elongated, brownish bump that looks like a miniature oystershell. These female scales are about ⅛ inch long. Males, which have two wings, antennae, and eyes, but no mouth, are rare.

The female lays eggs under her shell in late autumn, where they remain until they hatch in late May. The crawlers move around until they locate a suitable feeding site, then insert their mouthparts and begin to feed. Oystershell scale spreads during the crawler stage when wind, birds, large insects, and other moving objects transport the young scales. As the insect grows, the shell covering increases in proportion so that the body is always protected. The female loses her legs and eyes after molting from the crawler stage, and she becomes no more than a lump with a mouth. Most of her body is filled with 20 to 100 eggs which she lays in late autumn. She dies a short time later. There is one generation per year in the North.



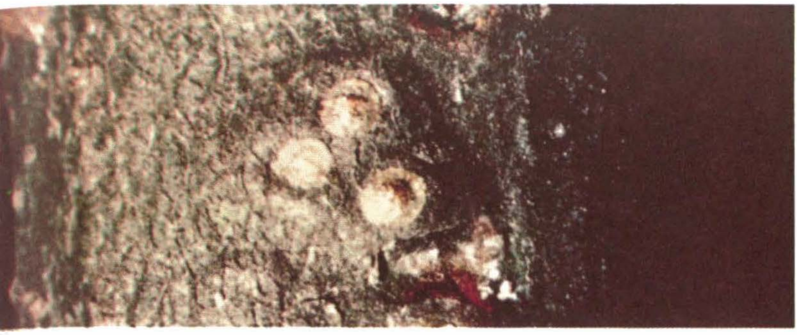
▲ **Adults and crawlers**

PIT-MAKING OAK SCALE *Asterolecanium minus*

This insect attacks most oak species. Light infestations cause trees to lose their vigor, and moderate to heavy infestations may kill branches or entire trees. Trees seem more susceptible to attack during dry weather.

The scale spends the winter as an adult or near-adult on trunks or branches. The damage it causes — a pit-like depression in the bark — is easily recognized. The adult scale is smooth, light yellowish to greenish, and about 1/25 inch wide. The female lays eggs in May and June. Eggs hatch in June and crawlers begin feeding on twigs and branches. As they feed, small pits develop that remain after the scale dies. There is one generation per year.

▼ **Adults**

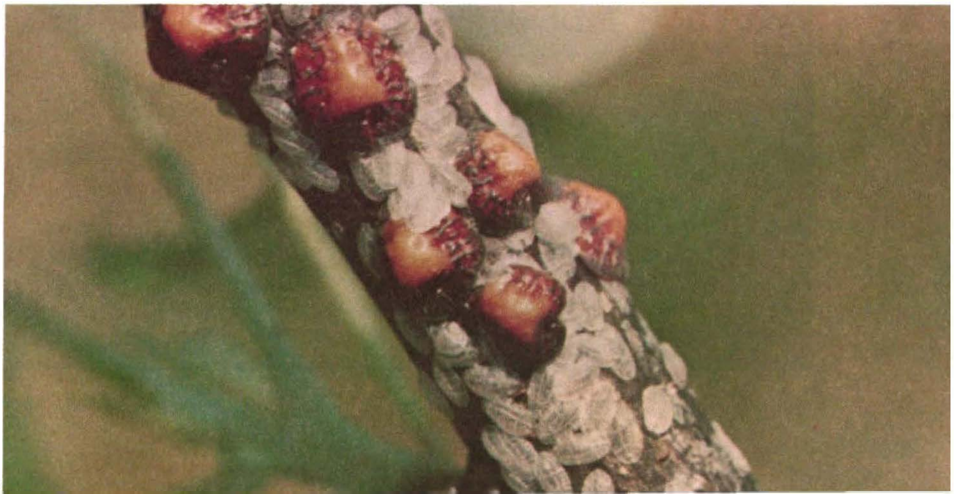


TULIPTREE SCALE *Toumeyella liriodendri*

This sucking insect, a major pest of yellow-poplar, may weaken, distort, or kill trees. Severe infestations also may limit tree regeneration. Other hosts include linden, walnut, and basswood.

The females bear living young in September and early October. A single female may have up to 3,500 crawlers over a period of 45 days. Crawlers are active for several days; during this time they may be dispersed from tree to tree by the wind. They later insert their mouthparts and overwinter. The partially grown or mature female scale is most noticeable; the latter is ¼ to ½ inch in diameter, hemispherical, and dark brown in color. The tuliptree scale normally has one generation per year.

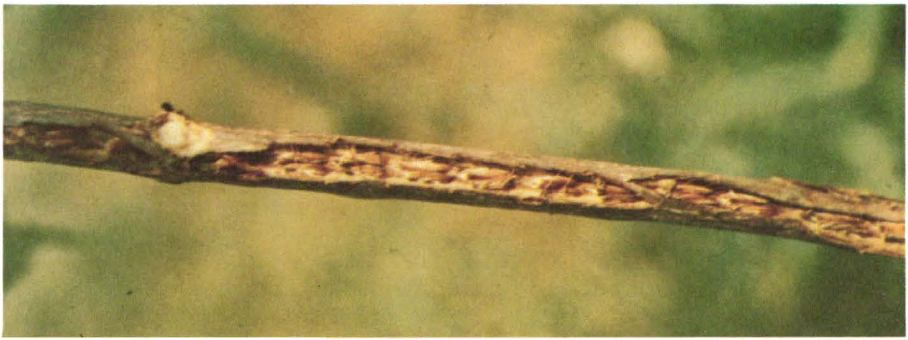
▼ **Adults and crawlers**



PERIODICAL CICADA *Magicicada septendecim*

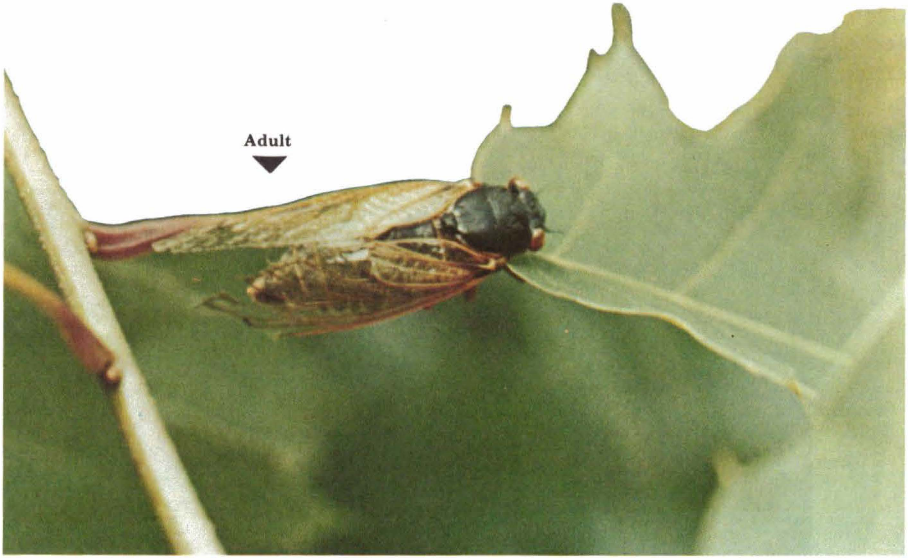
Oaks, hickory, honey locust, dogwood, apple, and peach seem to be the most susceptible to cicada attack, but several other tree species, such as elm, ash, sweetgum, sycamore, yellow-poplar, walnut, and redbud, may be affected. The adult female causes the damage by using her sawlike ovipositor to lay eggs in the bark of branches. The most serious damage, which appears in the form of flagging, wilting, and broken branches, is found on young, transplanted trees in nurseries and orchards.

Females lay eggs in pockets in the bark during April and May. When the eggs hatch, the nymphs fall and enter the ground, feeding on the roots of many plants. When nymphs are full grown, they emerge from the ground, climb on some object, and molt to become adults. The adults are about 1½ inches long. The female is completely black on top, while the male has four to five abdominal segments that are orange-brown on top. Sometimes the nymphal cast skin can be used to determine the causal agent of branch injury. Each generation requires 13 to 17 years.



▲ **Egg laying injury**

Adult ▼

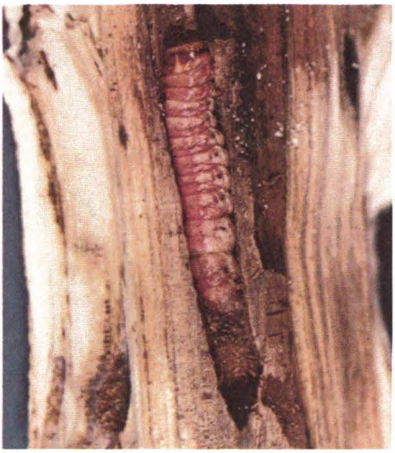


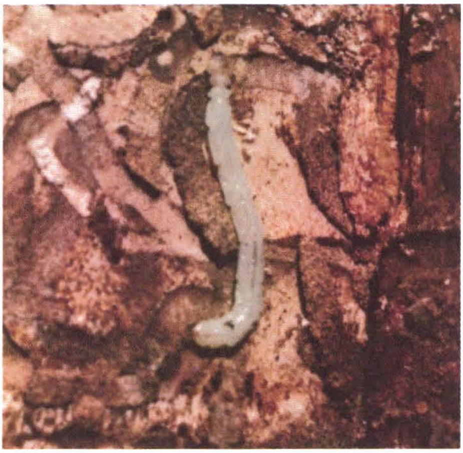
CARPENTERWORM *Prionoxystus robiniae*

This hardwood borer damages millions of dollars worth of sawtimber each year. Species in the red oak group are most heavily damaged, but additional hosts include black locust, cottonwood, elm, maple, and willow.

The mottled gray-black adult moths appear in late May or early June. Males have an orange spot on each hindwing; females are considerably larger than males, with an average wingspan of 3 inches. Soon after mating, females lay about 500 eggs in groups within bark crevices, inside cracks, under lichens, or in other secluded areas. Upon hatching, larvae move about on the bark surface searching for a suitable feeding site. Larvae range in color from pinkish orange to greenish white. When full grown, they average 2½ inches in length. The larvae gradually bore into the sapwood and heartwood, usually producing a sap stain on the outer bark. After a larval period of 2 to 4 years, the insects pupate deep within the heartwood and emerge as adults through large exit holes.

▼ **Larva**



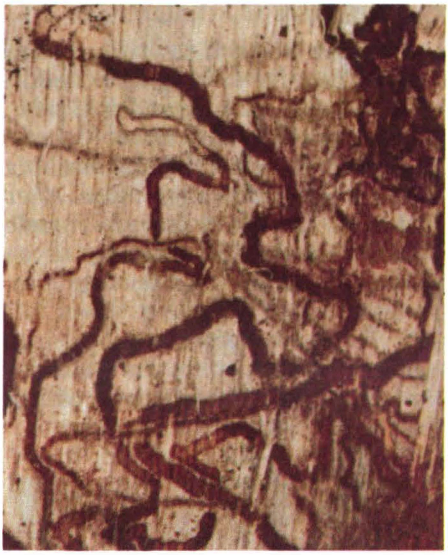


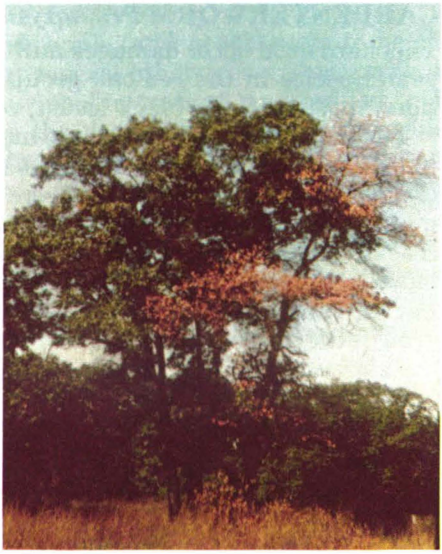
▲ **Larva**

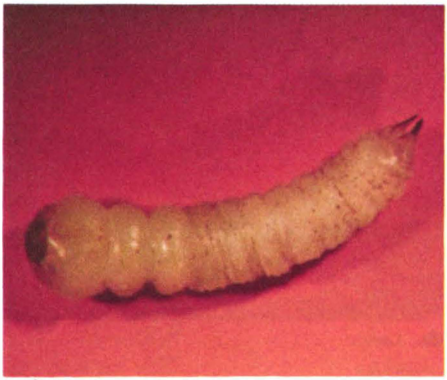
BRONZE BIRCH BORER *Agrilus anxius*

The bronze birch borer attacks weakened or injured yellow and paper birch trees, as well as gray birch, black birch, poplar, cottonwood, and willow. Usually, the first sign of infestation is browning of the foliage in the upper branches. The tree than slowly declines and eventually dies. Infested branches often appear swollen and discolored.

Full-grown grubs overwinter in cells within the sapwood. From late April until August, adult beetles emerge to lay their eggs beneath flaps of loose bark or lichen, or in cracks or crevices in the bark. The beetle is greenish bronze, ¼ to ½ inch long, with a blunt head and slender, pointed body. When the eggs hatch, tiny larvae bore their way to the inner bark. The larvae are slender with a slight enlargement of the body behind the head. They have two brownish spines at the end of their abdomens. In the fall, after forming cells in the sapwood, the full-grown larvae make galleries between the wood and the bark and pack them tightly with sawdust. These galleries run across the grain of the wood, often girdling the trees. Some galleries may be 4 feet or more in length. Two years are required to complete the life cycle in the North; there is one generation per year in the South.


▲ Galleries


▲ Damage


▲ Larva

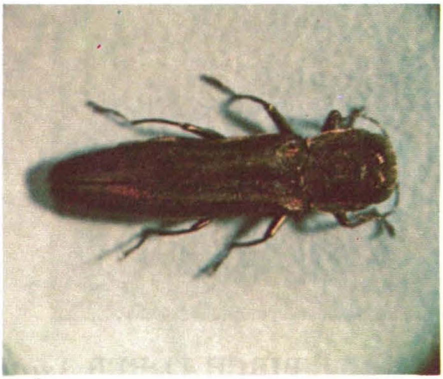
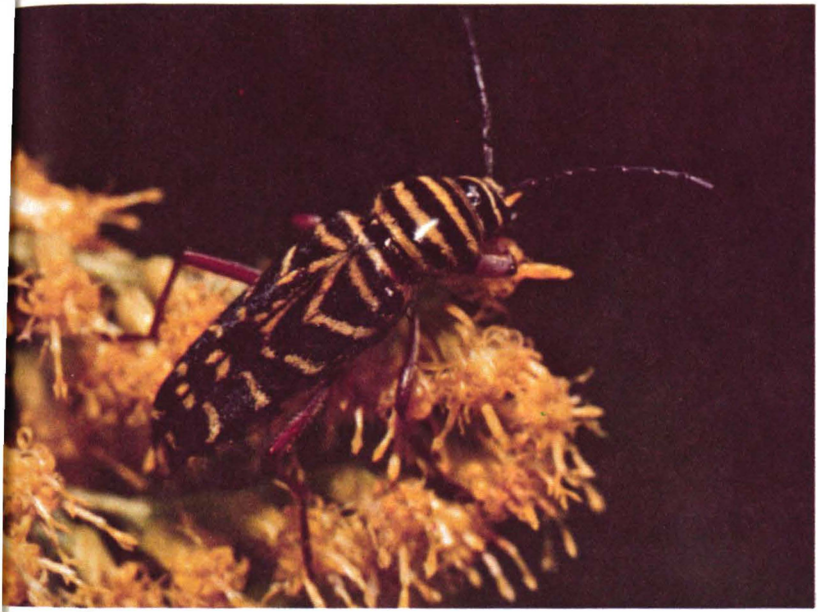

▲ Adult

Photo credit: Wilfred Cote, International Paper

TWOLINED CHESTNUT BORER *Agrilus bilineatus*

The twolined chestnut borer attacks various hardwoods, especially chestnut and several species of oak. Trees weakened by drought or defoliation are most susceptible to attack. Larvae mine in the inner and outer wood, and a heavy attack may girdle and kill the tree.

Beetles overwinter as pupae in cells constructed in the outer layers of sapwood and sometimes in the bark. In spring the adults emerge through characteristic D-shaped holes in the bark. Eggs are deposited on the bark in late spring and early summer. Young larvae bore directly through the bark to the phloem, where they excavate winding galleries in the inner bark and outer wood of the main trunk and larger branches. Mines run back and forth in all directions. Heavily attacked trees are girdled and eventually die. The attack usually begins in the top of the tree, extending downward as the tree weakens. In the North, the beetle has a 2-year cycle; in the South, only 1 year is required.

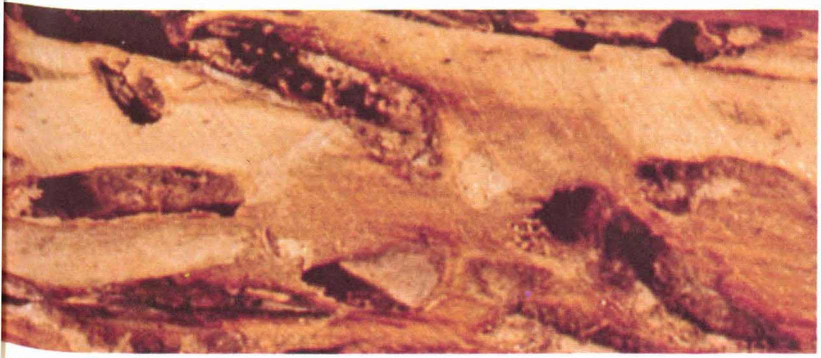


▲ Adult locust borer

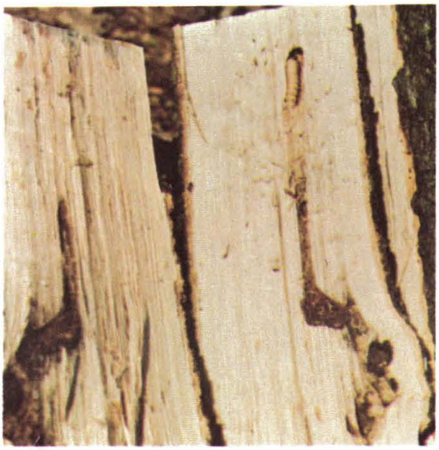
LOCUST BORER *Megacyllene robiniae*

The locust borer, one of the long-horned, wood-boring beetles, is a serious pest wherever black locust is found. Infestations lower sawlog quality, reduce growth, and make trees more susceptible to wind damage. Signs of attack include swelling and sap stain on trunks and branches.

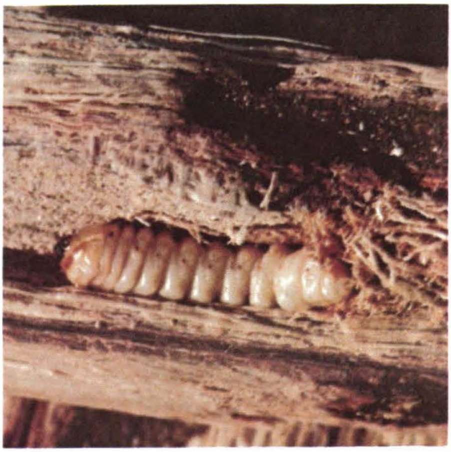
Young larvae overwinter in a shallow bark cell, become active in the spring, and work their way into the sapwood and heartwood. Larvae are fleshy, larger at the front, and pale white to light yellow. Extensive tunneling continues until mid-summer, when the larvae pupate; adults emerge in August and September. The ¾-inch-long adults, which are characterized by yellow lines on black wing covers, can frequently be seen feeding on goldenrod pollen during early morning. Soon after mating, females lay their eggs in small batches within bark crevices. Larvae hatch in about 1 week and soon construct individual bark cells in which they overwinter. There is one generation each year.



▲ Galleries



▲ Red oak borer larval damage



▲ Red oak borer larva

▲ White oak borer adult exit hole

RED OAK BORER *Enaphalodes rufulus*
WHITE OAK BORER *Goes tigrinus*

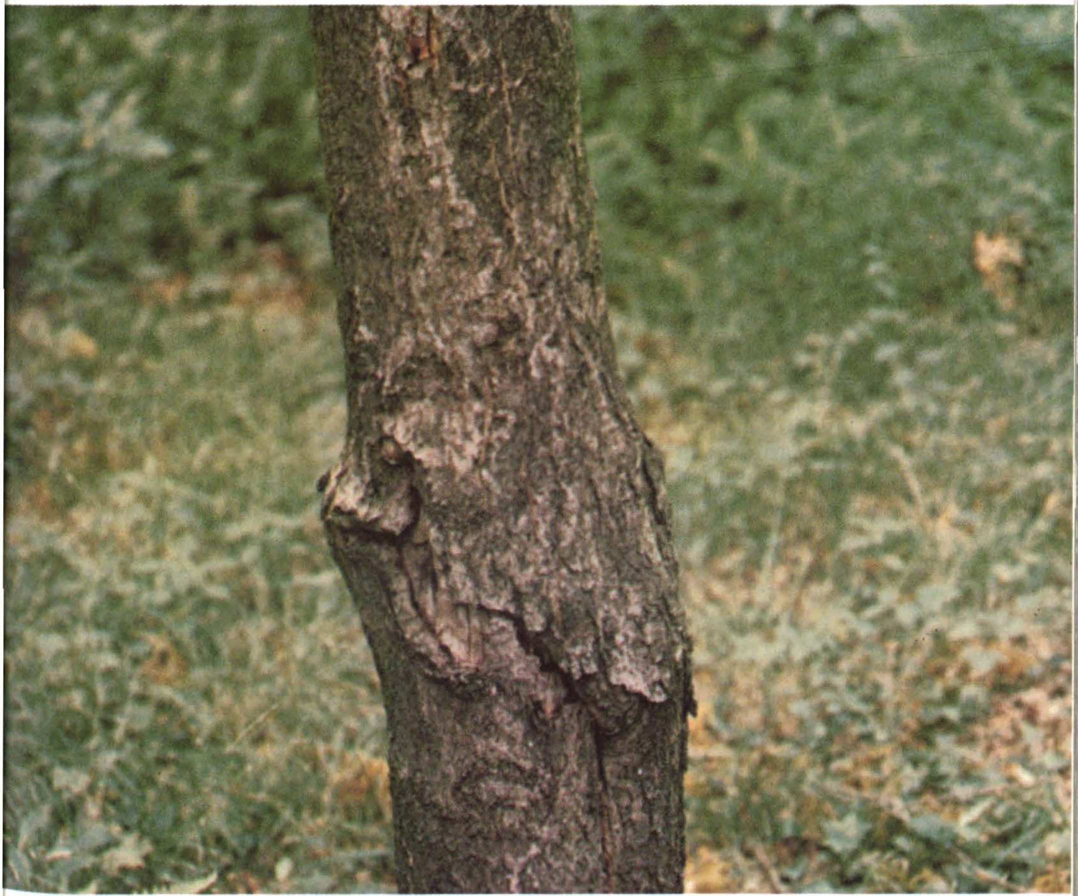
These two long-horned, wood-boring beetles annually account for enormous losses within the hardwood timber industry. True to their names, preferred hosts are species within the red oak group and white oak group, respectively.

Females lay eggs in pits chewed through the outer bark or within bark crevices. In a few weeks the eggs hatch, and the larvae bore directly into the phloem. Eventually they tunnel into the wood, destroying its sawtimber value. Adult red oak borers are light brown, 1 inch long, and have an almost even distribution of fine, white hairs. White oak borers are dark brown, about 1¼ inches long, and are mottled with patches of white. Larvae of both are full-bodied, cream to yellow, and larger at the anterior. The life cycle of the red oak borer requires 2 years; most adults emerge in odd-numbered years. The life cycle of the white oak borer requires 3 to 5 years, depending on location.

SUGAR MAPLE BORER *Glycobius speciosus*

The sugar maple borer is distributed throughout the northeastern states wherever sugar maple, its only known host, is found. Injury is indicated by ridges or raised areas on the trunk and large limbs, and sawdust-like frass and moisture on the bark.

Eggs are deposited in bark crevices, under bark scales, or around wounds, usually during July and August. The larvae feed beneath the bark. The insect spends the winter as a larva in a chamber formed in the sapwood. The following spring, it resumes feeding. As the second winter approaches, the mature larva bores deep into the wood and constructs a pupal cell. Before entering the cell, the larva cuts an exit hole through which it will emerge as an adult in the spring. The adult is a robust, velvety-black beetle about an inch long. Its head is covered with fine, yellow hairs. Its back is marked with several yellow bands, those near the front forming a characteristic w-shaped design. The life cycle requires 2 years.



▲ **Damage**

ANTHRACNOSES

The hardwood tree leaf diseases called anthracnoses are caused by fungi of the genera *Gloeosporium* and *Gnomonia*. Affected host trees include ash, basswood, birch, catalpa, elm, hickory, horsechestnut, maple, oak, London plane, sycamore, yellow-poplar, and walnut. The disease is particularly harmful to American sycamore, white oak, other oaks in white group, and black walnut. Symptoms generally include dead spots on the leaves or dead leaves, premature defoliation, formation of twig cankers, and twig dieback.

The fungi that cause anthracnoses have both sexual and asexual stages. The fruiting bodies appear as tiny specks on killed areas. The fungi overwinter in fallen leaves and cankered twigs still on the tree. Sexual spores, produced in small, dark, fruiting bodies on these leaves or twigs, are responsible for infection in the spring. Air currents carry the spores to newly developing leaves. Late-summer infections arise from asexual spores produced in the spring. The spores are splashed about by rain, causing new infections.

SYCAMORE ANTHRACNOSE (A)

Sycamore anthracnose is caused by *Gnomonia platani*. The hosts include American and European sycamore and London plane. Leaves, twigs, buds, and shoots are infected.

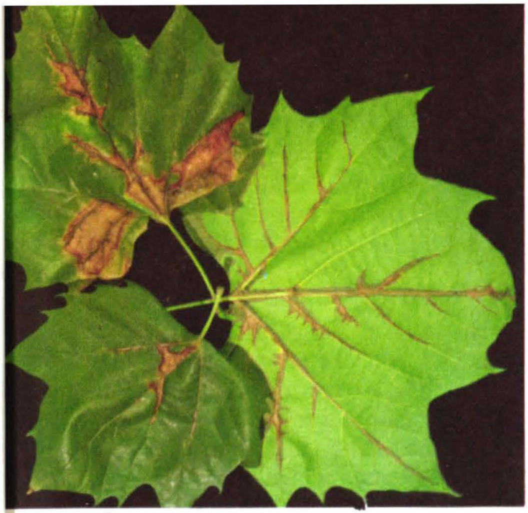
Twig blight occurs in spring before the leaves emerge. Cankers may appear later on older branches below the dead twigs, sometimes girdling and killing them. Bud blight occurs in April or early May. Shoot blight, which is often confused with frost damage, is most severe when the mean daily temperature is 50 to 55°F; it seldom occurs when the temperature is higher than 60°F. Sycamore anthracnose is common throughout the range of sycamore in the eastern United States.

Small, black fruiting bodies are found on twigs killed by the fungus during the twig blight stage. Dark-brown fruiting bodies appear in the diseased tissues along the midribs and veins on the undersides of infected leaves.

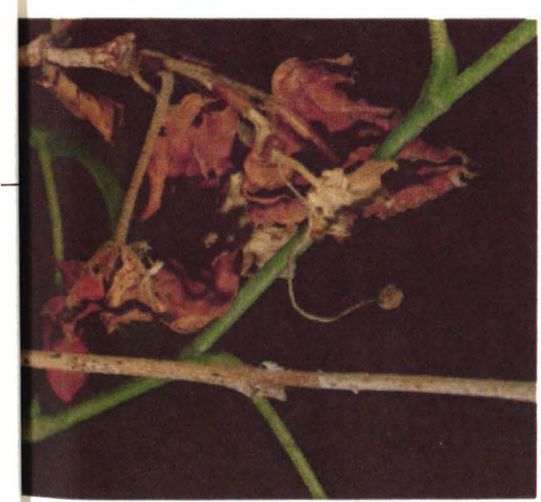
OAK ANTHRACNOSE (B)

Oak anthracnose, caused by *Gnomonia quercina*, affects white oak and other oaks in the white oak group. Trees growing at the edge of a stand or in the open are affected more severely than those in forest stands.

Anthracnose begins as irregular areas of dead tissue along the midribs and veins of infected leaves. Severely infected leaves become curled and twisted, and in wet years premature leaf fall may occur. Emerging oak leaves that are attacked but not killed may be distorted. Leaves on the lower branches generally are more severely affected than those on the upper branches. The pathogen may spread into the twigs and form cankers that can cause some twig dieback.



▲ Infected leaves (A)



▲ Cankers and affected leaves (A)

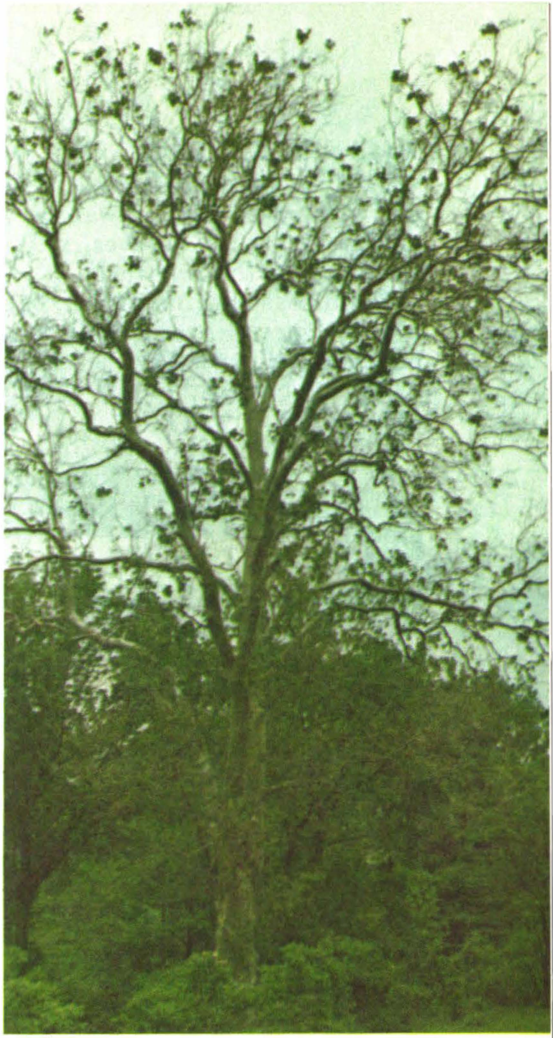
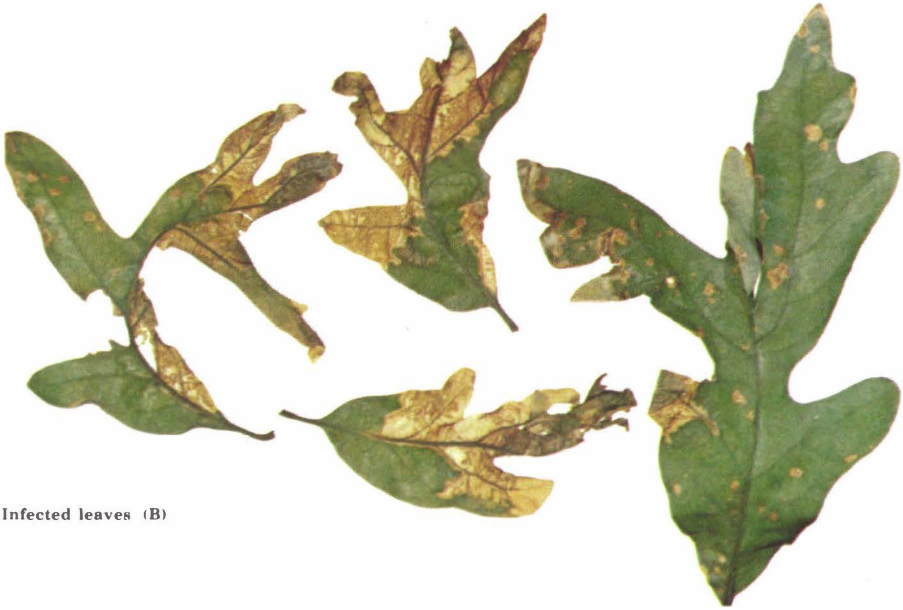


Photo credit: Cornell Univ.

▲ Defoliated tree (A)



Infected leaves (B)

WALNUT ANTHRACNOSE (A)

Walnut anthracnose, caused by *Gnomonia leptostyla*, affects black walnut, butternut, Persian walnut, and first-generation hybrids of Persian and black walnut. Leaves, nuts, and sometimes shoots of the current season's growth are attacked.

The disease begins as tiny, dark spots on infected leaves. These spots usually spread over the leaves until they form large dead areas or blotches. Yellowish to gold leaf tissues usually border these spots.

Anthracnose can be epidemic in wet weather, causing premature foliage loss as early as late July or early August. Such defoliation slows the tree's growth, weakens the tree, and sometimes kills it. The nuts of diseased trees have dark, unattractive, shriveled meats and sunken dead spots on the hull. The fungus overwinters in infected leaves on the ground.

MAPLE ANTHRACNOSE (B)

Maple anthracnose, caused by *Gloeosporium apocryptum*, is confined to Norway maple, sugar maple, and Japanese red maple. When conditions are wet enough, the disease can kill a great number of leaves and even entire trees.

Purple-to-brown dead areas appear along the veins of infected Norway maple leaves. On sugar maple leaves, large, irregular green-brown or red-brown dead areas form along and between the veins and extend out to the edges of the leaves. On Japanese red maple, irregular light- to dark-brown dead areas form at the base of the leaves.

Symptoms of anthracnose in sugar maple may be confused with symptoms of leaf scorch, a condition resulting from drought and heat injury, but with anthracnose, small, brown fruiting bodies form along the veins of leaves. Fruiting bodies of the fungus on Norway maple are also brown, while those found on Japanese red maple are dark brown to black. The fungus overwinters primarily in fallen leaves.

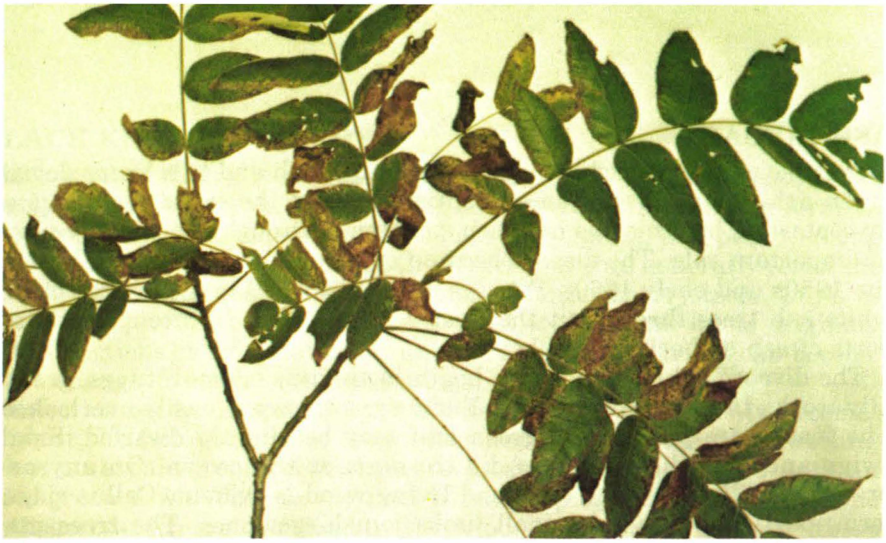
ASPEN SHOOT BLIGHT (C)

Aspen shoot blight is caused by *Venturia populina* on balsam poplar and the closely related *Venturia tremulae* on quaking and bigtooth aspen. These fungi, which occur throughout the range of balsam poplar, quaking aspen, and bigtooth aspen, cause leaf spots and kill the shoots.

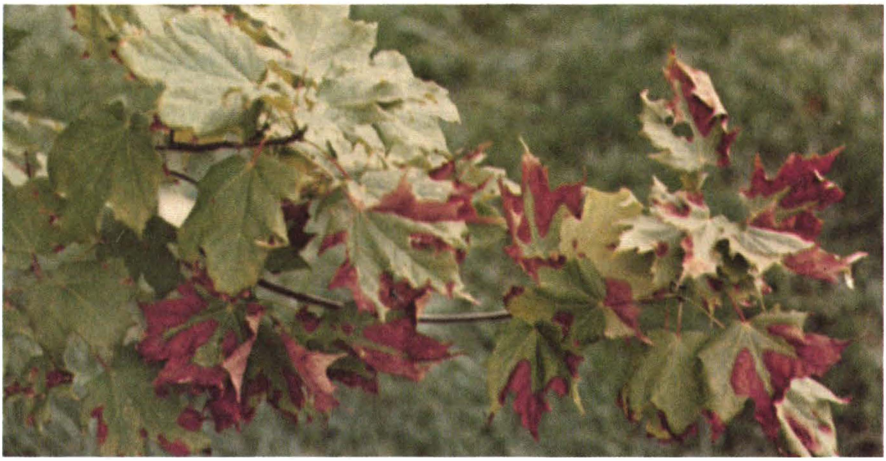
The symptoms produced by both fungi are similar. Angular leaf spots form in early summer and enlarge until the entire leaf is blackened and wilted. The fungus spreads down the stem of the leaf (particularly on quaking aspen) and blackens the shoot. The shoot then withers and forms a characteristic "shepherd's crook." Under moist conditions, dark-greenish spores form on the infected leaves and shoots.

Severe outbreaks of this blight rarely occur in successive years, and the fungus invades and kills only the current year's tissue. The repeated loss of current growth can cause stag-headed trees and delay tree harvest, but trees older than 5 years are seldom affected. Therefore, the disease is of little economic importance in natural stands.

Photo credits: Cornell University

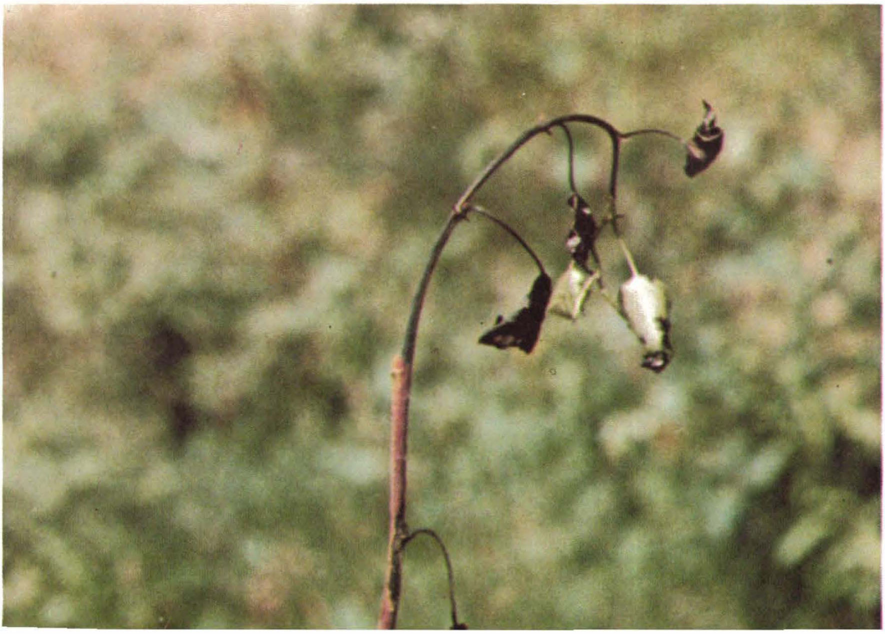


▲ Infected leaves (A)



▲ Infected leaves (B)

▼ Infected shoot and leaves (C)

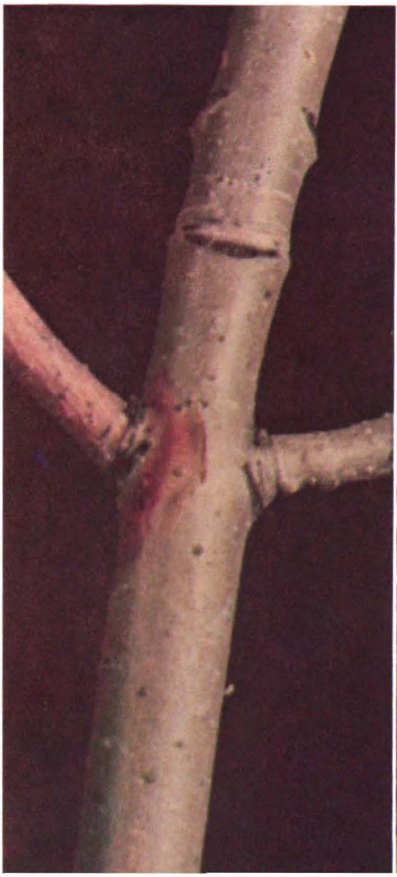


ASH DIEBACK

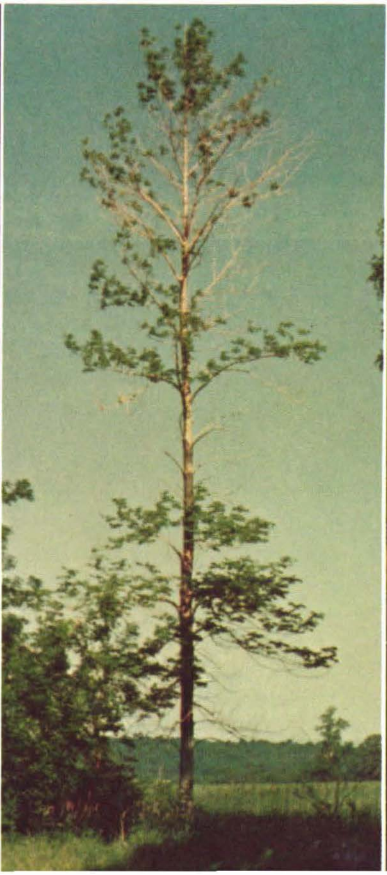
The cause of ash dieback, which affects white ash and to a lesser degree green ash, is unknown. Some scientists suspect the cause is a virus or mycoplasma, but this has not been confirmed. Drought apparently plays an important role. The disease became epidemic throughout the East in the 1950s and early 1960s. Surveys showed that 20 to 30 percent of the white ash trees throughout the East were affected. In recent years, reports of ash dieback have subsided.

The disease, which appears to begin in the tips of small twigs, gradually works into larger branches. Early symptoms are easily overlooked. The leaves are pale yellow-green and may be slightly dwarfed. Small twigs and branches begin to die throughout the crown. On any one branch, the line between dead and living wood is evident. Callus ridges form, particularly where small limbs join larger ones. The trees may produce epicormic branches or "water sprouts" along the trunk or on the branches. Yellowish- to reddish-brown sunken cankers form on dying twigs and branches. The cankers are caused by the fungus *Cytophoma pruinosa,* a weak pathogen that hastens the death of twigs and branches.

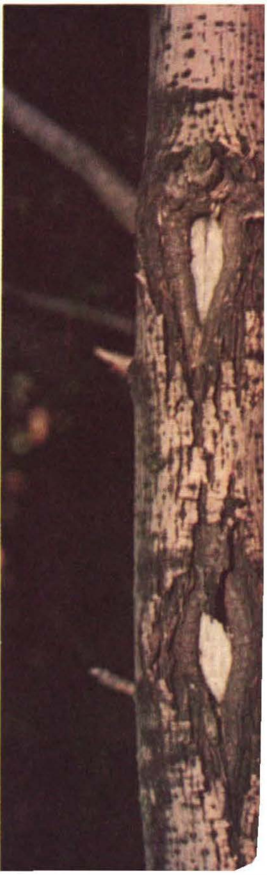
Eventually the crown becomes thin and tufted, and the leaves and leaflets dwarfed. The foliage in the stag-headed crown may be reduced to a small area near the top of the tree. Many trees die 2 or 3 years after symptoms appear; others linger for 10 years or longer. Infected trees apparently do not recover.



Sunken canker



Affected tree

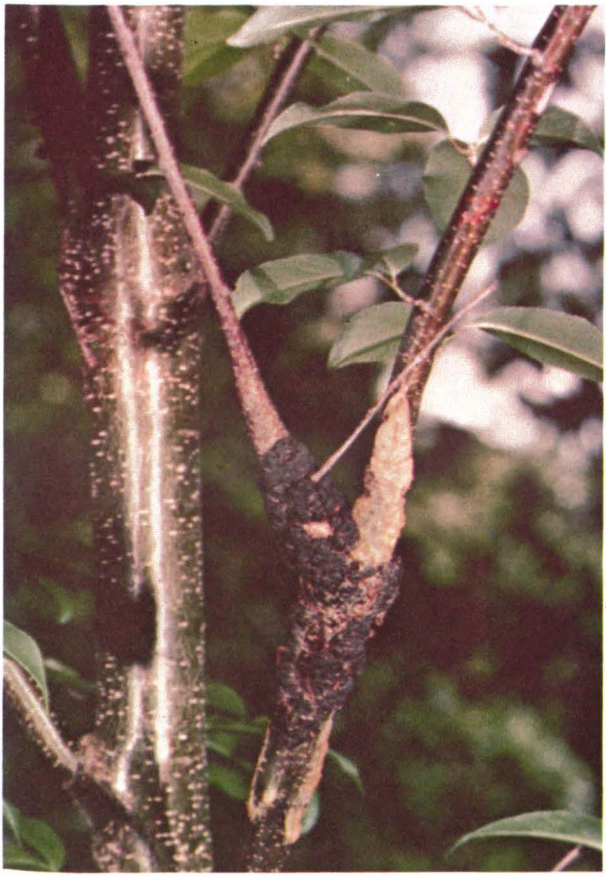


Old cankers

BLACK KNOT OF CHERRY

Black knot of cherry is caused by the fungus *Apiosporina morbosa,* formerly called *Dibotryon morbosum*. Black charcoal-like tumors form on the hosts, which include all varieties of cherry, plum, and peach. Young shoots can be killed in a year, but the larger branches generally resist the attack for several years. On the trunks of larger cherry trees, burls or swellings up to 6 feet long can form. Most of the trunk knots originate with infections on small lateral branches. Knots on the trunk can become large enough to render the wood unusable.

Infection occurs in spring, but the swelling that follows only becomes evident the following year. Soon after becoming visible, the swelling takes on a pale-green color, then cracks and becomes covered with an olive-green down. This downy coat is made up of asexual spores of the pathogen, which are dispersed by the wind. At the end of summer, these spores stop forming and the olive-green down disappears. The swelling hardens and progressively blackens. In winter the ascospores (spores of the sexual stage) develop in small, globular fruiting bodies that form on the knots, giving them a gnarled appearance. The following spring these ascospores are dispersed by the wind to neighboring healthy branches. New infections are produced, and the 2-year cycle is thus completed.



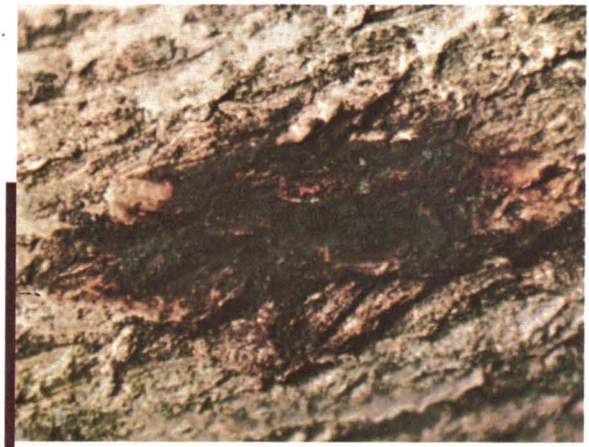
◀ **Black knot of cherry**

BUTTERNUT DIEBACK

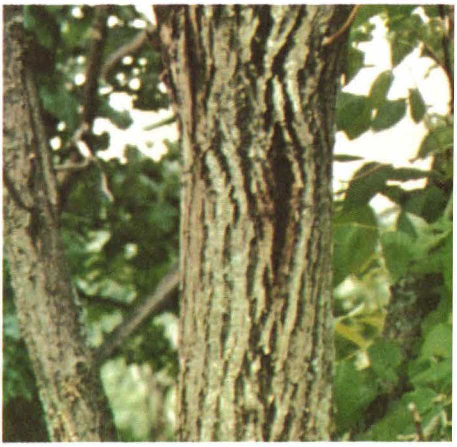
Dieback and decline of butternut was first described in 1923, but reports of the malady go back to the turn of the century. The causal organism was at first thought to be *Melanconis juglandis*, a weak pathogen found throughout the butternut range. However, *Sirococcus clavigignenti-juglandacearum* has recently been found to produce a canker that leads to the decline; *M. juglandis* is secondary.

The first symptom of decline is branch dieback; *M. juglandis* usually is found fruiting on the dead twigs. Annual stem and branch cankers form and normally the bark splits at the point of the canker. A black substance oozes from the canker. Epicormic branching is common, and tufts of live branches form along the bole before the tree dies. No sexual stage of the fungus is known. The asexual spores are spread locally by blowing rain. The mode of long distance spread is unknown.

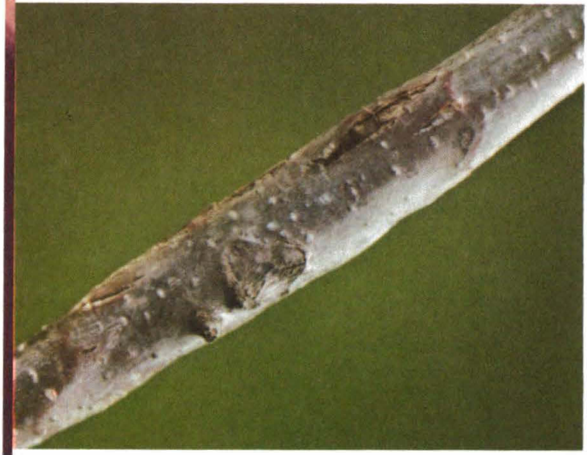
Butternut dieback probably is responsible for the present scarcity of butternut in the eastern states. The disease is now causing severe losses in the Midwest and is seriously threatening the survival of the species.



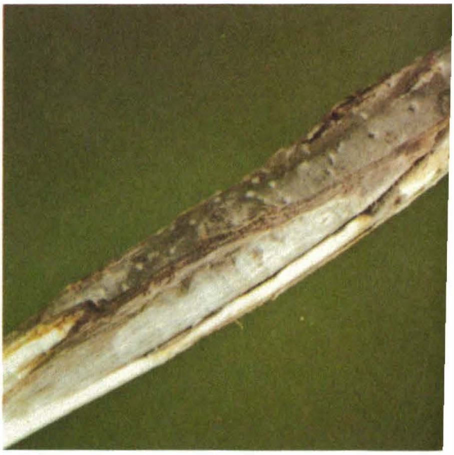
▲ **Oozing canker**



▲ **Stem canker**



▲ **Branch canker**



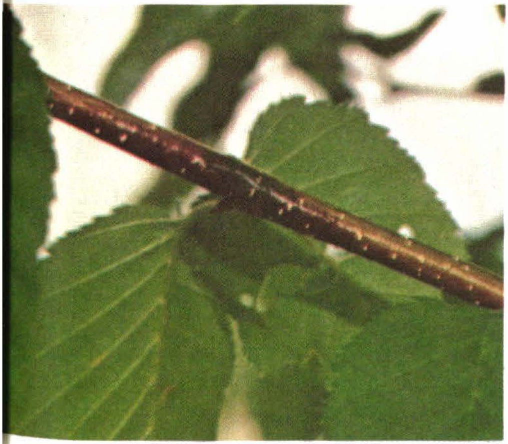
▲ **Exposed canker showing extent of injury**

YELLOW BIRCH CANKER AND SHOOT BLIGHT

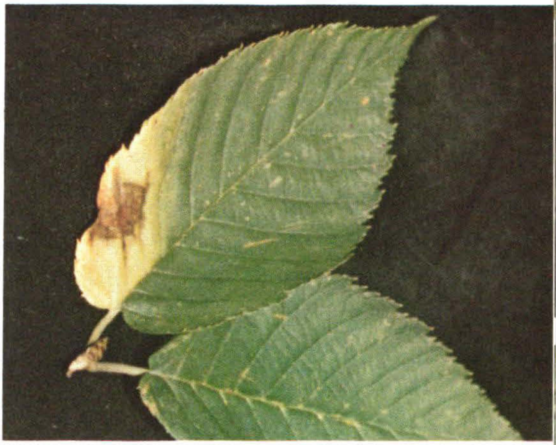
Canker and shoot blight of yellow birch may be caused by either *Diaporthe alleghaniensis* or *Gnomonia setacea*. Yellow birch is susceptible to these fungi until the trees are about 3 inches in diameter.

From spring to early summer, both fungi cause black, sometimes sunken cankers in the outer bark. Later the fungus spreads to the inner bark and may discolor nearby wood. New shoots are infected and killed early in the growing season, sometimes forming "shepherd's crooks." Because it takes longer for a canker to girdle the older, woody stems, these stems die later in the year. The leaves beyond the canker wilt, and the dead leaves remain attached to the tree for several months. Fruiting bodies form within the dead stem bark and burst out.

Leaf spots are caused only by *Gnomonia setacea*. They may appear at any time during the growing season, but most often in the latter half. The brown spots usually are surrounded by yellowish zones. Small, black fruiting bodies develop within the leaf spots and dead stem bark.

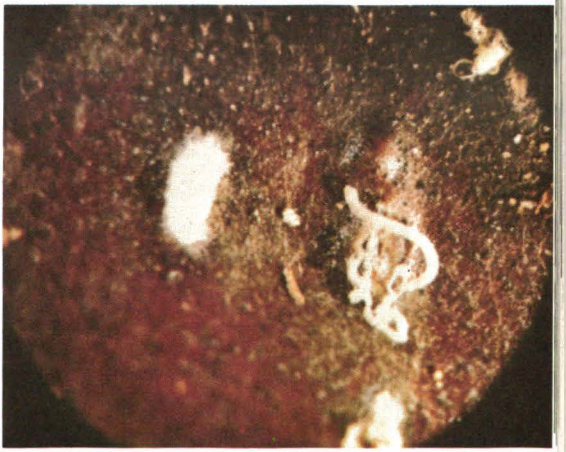


▲ **Canker**



▲ **Leaf spot**

▲ **Wilting tree**



▲ ***Diaporthe* fruiting bodies**

HYPOXYLON CANKER OF ASPEN (A)

Hypoxylon canker of aspen, caused by the fungus *Hypoxylon mammatum,* is one of the most serious diseases of aspen in the United States. The disease abounds east of the Rocky Mountains wherever aspen occurs. Of the native poplars, quaking aspen is very susceptible, bigtooth is moderately susceptible, and balsam poplar is rarely infected. There are marked differences in clone susceptibility.

A young canker begins on the bark as a slightly sunken, yellowish-orange area with irregular margins. As the infection spreads, the outer bark blisters and drops off to expose the pillars formed by the fungus. Three years after infection, small patches of hard, gray, raised fruiting structures develop where the fungal pillars were found previously. Old cankers, which may be several feet long, are rough and blackened in the center. The older cankers have margins that are characteristic of young cankers. Cutting into the diseased bark of the young cankers or near the margin of older cankers reveals a white mycelial fan.

The mode of spread is unknown. Attempts to infect trees artificially with sexual spores (acospores) have been unsuccessful. The wounds caused by poplar borers (for example *Saperda inornata*) and other insects provide entry points for the fungus.

CYTOSPORA CANKER OF POPLAR AND WILLOW (B)

Cytospora canker is caused by the fungus *Cytospora chrysosperma* (the sexual stage is *Valsa sordida*). Poplars, aspens, and willows are the most commonly affected trees.

Cytospora canker is confined to weakened trees. The fungus enters the tree through a wounded or weakened twig and kills the twig back to a larger branch or the trunk. Brownish, circular-to-oval cankers with sunken bark are formed in the smooth bark of branches and trunks. The diseased area gradually enlarges, and frequently stems are girdled and killed. When the older trunk or large branches are attacked, the inner bark blackens and gives off a disagreeable odor. Severely attacked trees 3 to 6 inches in diameter die in 2 or 3 years.

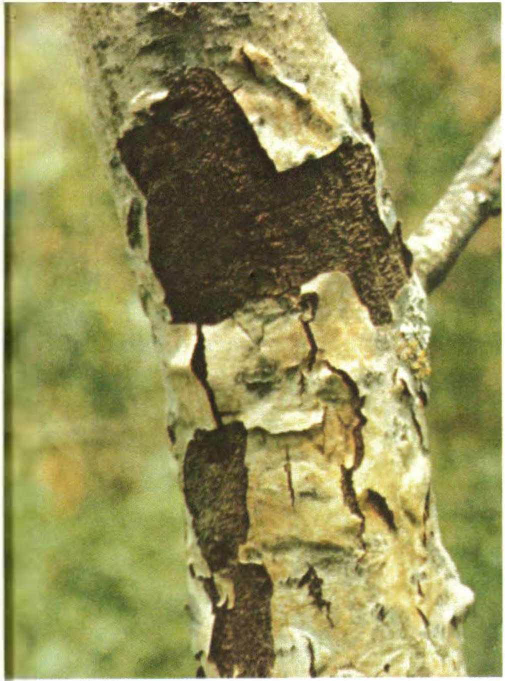
The fungus produces small fruiting bodies in the diseased bark. Spores are splashed by rain or carried by wind, birds, or insects to other trees.

SEPTORIA CANKER OF POPLAR (C)

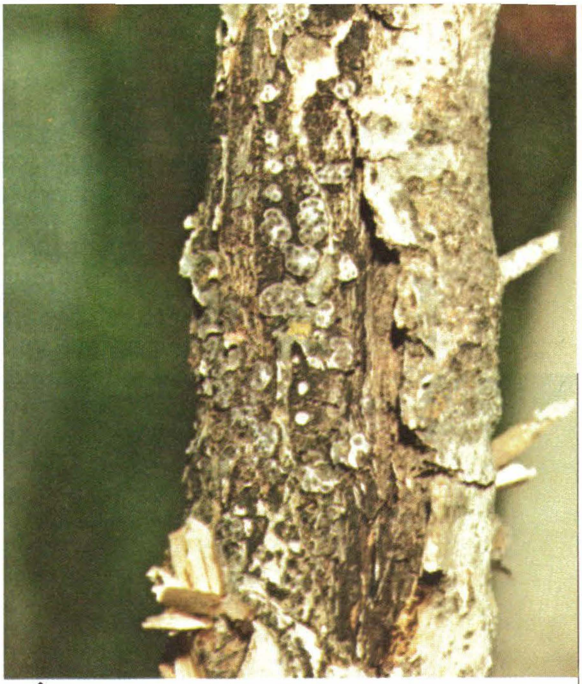
Septoria canker of poplar is caused by the fungus *Septoria musiva*. Certain native hybrids, particularly those bred from black poplar, balsam poplar, or cottonwood, and certain foreign hybrids (especially "Russian poplar"), are highly susceptible.

The fungus causes brown leaf spots with yellowish or white centers. These spots may affect as much as half of the leaf tissue. Cankers are formed in twigs of the current season's growth. The fungus does not girdle stems, but the cankers may allow entry of other fungi that do girdle stems, such as *Fusarium*.

Small, black, asexual fruiting structures develop on both cankers and leaves. In summer, under favorable conditions, asexual spores are spread to other places on the tree or to other nearby trees. *S. musiva* overwinters in tiny, black, flask-shaped sexual fruiting bodies on branches and fallen leaves. The sexual spores are shot into the air during periods of high humidity in the spring. They infect new leaves as the buds are opening. They also may infect young shoots and form cankers.



▲ Canker — asexual stage (A)



▲ Canker — sexual stage (A)

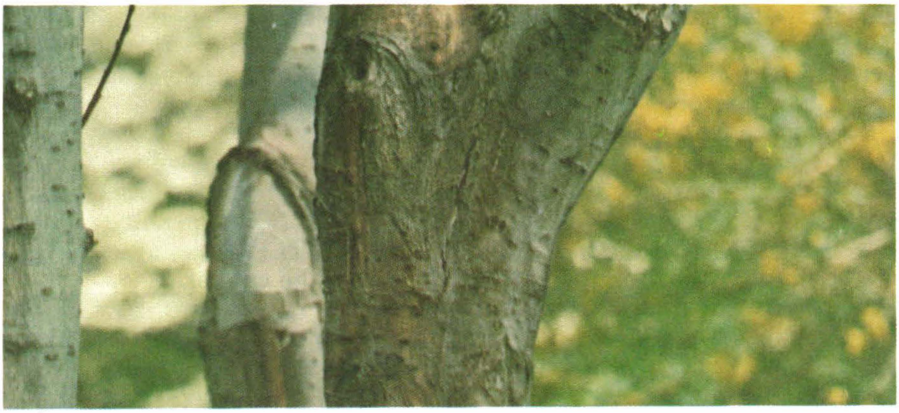
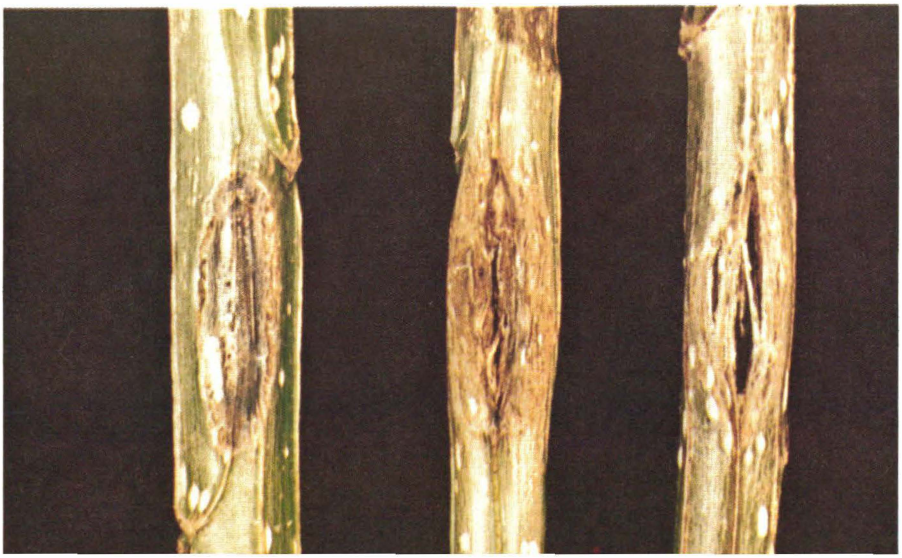


Photo credit: Cornell Univ.

▲ Cankers on poplar (B)

▼ Cankers on poplar (C)



FUSARIUM CANKER OF YELLOW-POPLAR (A)

Fusarium canker of yellow-poplar is caused by the fungus *Fusarium solani*, which also causes cankers on sugar maple, sweetgum, and true poplars (*Populus*).

The fungus enters the tree through broken branches, dead water sprouts, or bark wounds, especially those made by ambrosia beetles (which are possibly vectors). First, small vertical cracks form in the bark. These cracks become cankers up to a foot in length; separate cankers often merge. Infected tissues commonly ooze in the fall. Foliage does not appear to be damaged in the early stages of the disease, but as the cankers enlarge and kill more bark, the crown of the tree begins to thin and die back.

Cankers that form during the growing season (April to July) usually callus over with no canker activity the spring of the following year. Cankers that form in September may be still active 2 years later.

EUTYPELLA CANKER (B)

Eutypella canker, caused by the fungus *Eutypella parasitica*, is a common disease of maple trees. All maples are susceptible, sugar maple more so than others. The disease is found throughout the northern half of the range of sugar maple. It attacks primarily saplings or small sawtimber-sized trees, and usually affects only scattered trees within a stand.

The first symptom is a callus formation around an infection point, usually at a branch stub or wound. A sunken, dead area develops in the center of the callus and expands as the fungus grows outward. Broad, slightly raised areas of callus tissue may cause a wave-like appearance on the canker face. In later years the cankered area may form a hump, as the tree responds to invasion of the fungus. Dry, flinty bark normally remains attached to the face of the canker for many years. White mycelial fans can be found by cutting the callus tissue from the canker.

Black fruiting bodies develop in older cankers and release wind-dispersed spores. The spores are thought to infect other trees through openings in the bark such as branch stubs, logging wounds, sunscald, and frost cracks.

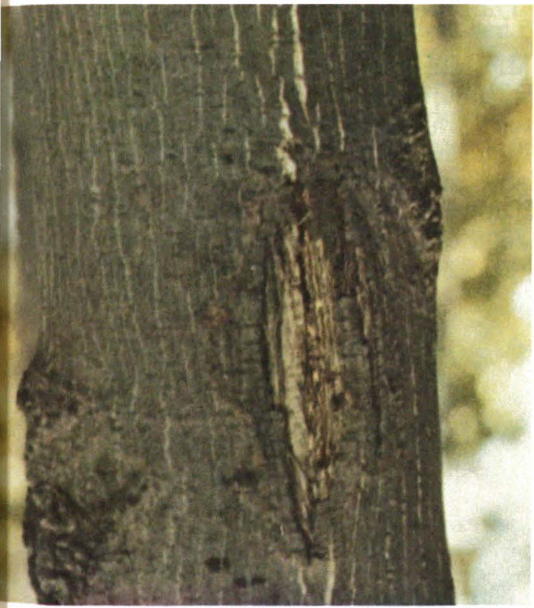
CHESTNUT BLIGHT (C)

Chestnut blight, caused by the introduced fungus *Endothia parasitica*, was first reported in the United States in 1904. Within 50 years, it had spread through the entire range of American chestnut, killing nearly all of the trees. The fungus also attacks European chestnut and post oak, and causes slight injury to maple, hickory, and sumac trees. Many attempts have been made to develop a variety of American chestnut resistant to blight, but none has been successful.

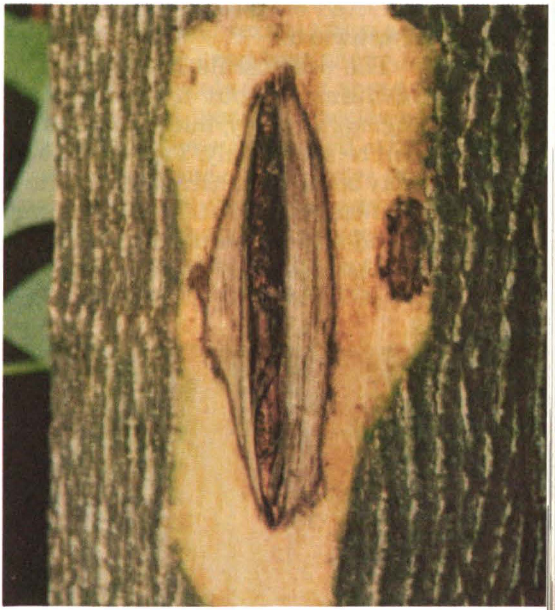
The fungus enters through wounds and produces cankers on branches and stems. Branch cankers kill the branches, causing the leaves to turn yellow and wilt. Stem cankers girdle and kill the entire tree. Sprouts often grow from the stumps of killed trees. These sprouts also become infected and eventually die.

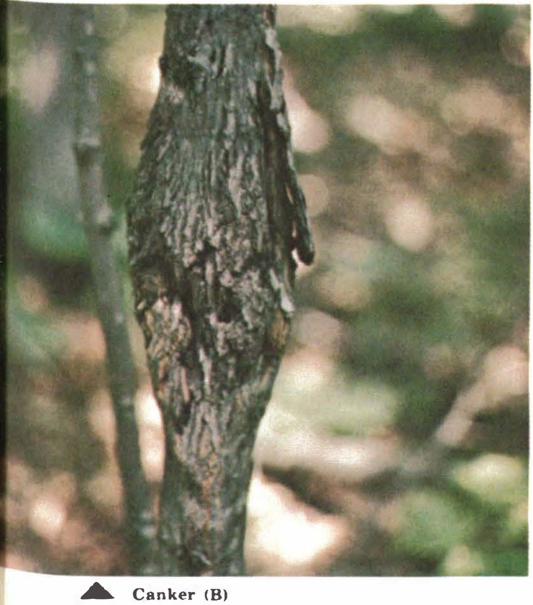
Cankers on young trees and branches are yellow-brown. Fruiting bodies develop on the bark at the canker. On older trees, the thicker bark splits up and down, and fruiting bodies develop in the cracks. Asexual fruiting bodies (pycnidia) develop, appearing as minute, orange blisters. They release spore masses in wet weather forming curled, yellow-orange tendrils called "spore horns." These sticky spores are dispersed by rain, insects, birds, and other animals. Sexual fruiting bodies (perithecia) are tiny flask-shaped pustules that produce ascospores. The ascospores are wind-dispersed.

▼ **Cankers on stem (A)**

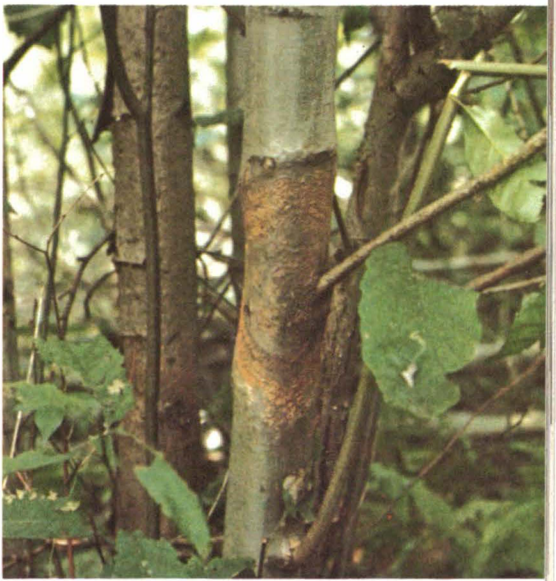


▼ **Exposed canker (A)**





▲ **Canker (B)**

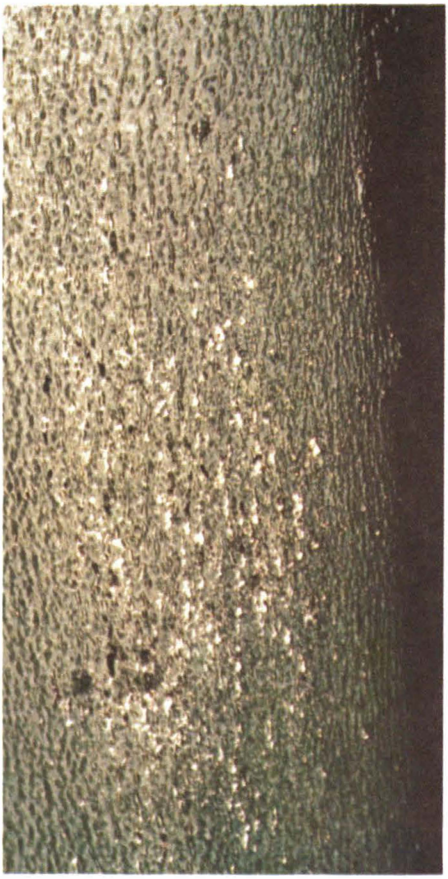


▲ **Infected tree (C)**

BEECH BARK DISEASE

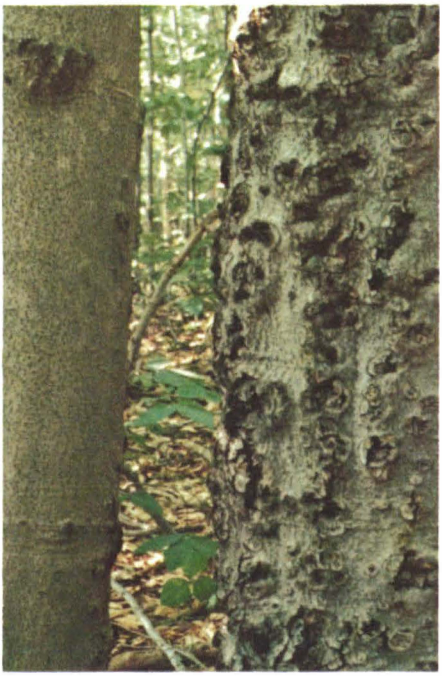
Beech bark disease is an insect-fungus "complex" that kills or injures American beech. Disease results when a species of *Nectria*, especially *N. coccinea* var. *faginata*, infects the bark of the trunk through feeding wounds made by the scale insects *Cryptococcus fagisuga* and *Xylococculus betulae*. Within the range of the disease, few large beeches escape injury. In 1975, the "killing front" was in eastern Pennsylvania and western New York, the disease having spread about 500 miles since it was first detected on the East Coast in 1929. The spread continues westward and southward.

The beech scale, *C. fagisuga*, usually infests trees more than 8 inches in diameter, but it is also found on smaller trees. An individual *C. fagisuga* is tiny, but the insect secretes a white, woolly wax covering that can be seen easily. The insects may cluster in cracks or under branches, or may cover the entire trunk. The scale reproduces asexually (no males are known). Eggs hatch in late summer, and the larvae crawl and disperse. Wind and perching birds help to spread the insects. During winter the scales lose their legs, secrete their protective covering, and pierce the



◀ **Scale insects**

▼ **Bark injury**



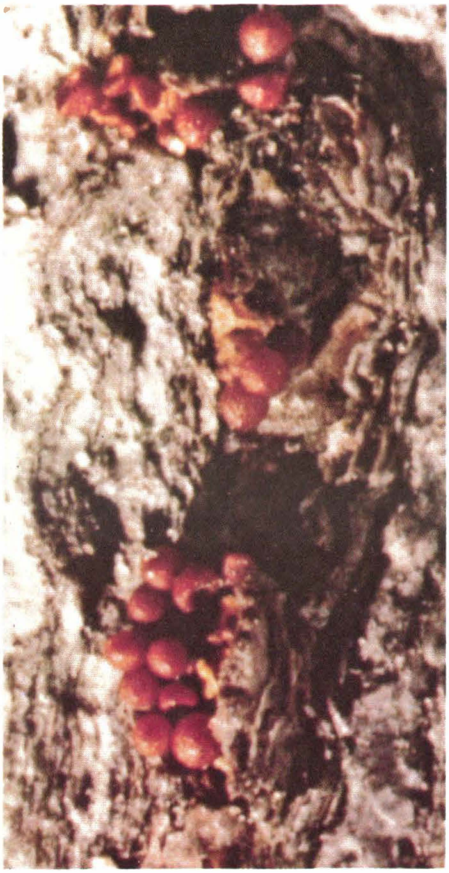
bark to feed. Thereafter they do not move. The insects can no longer live where the fungus has killed the bark.

X. betulae has a life cycle similar to that of *C. fagisuga*. The scale is red-orange, but after it becomes stationary in a crevice, it secretes a white wax to cover itself. The scale may be detected by hair-thin tubes that project from crevices in the bark. These insects produce additional wounds for the fungus to invade.

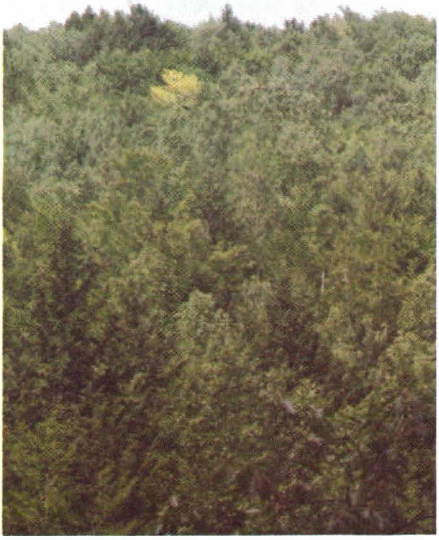
The asexual stage of *Nectria* produces a cushion of white spores during wet weather in the summer. These cushions resemble the woolly secretions of *C. fagisuga*. The small, red fruiting bodies of the sexual stage are found in clusters. They mature in the fall and can be seen best then.

Fungal invasion is apparent 3 to 5 years after the scale insects appear. Dark, dead patches are produced where other fungi, such as species of *Hypoxylon*, enter. *Nectria* infection points may become walled off with callus tissue, giving the tree a "pock-marked" appearance. Some trees are killed within a year after *Nectria* is apparent; others linger for several years. The leaves of the latter turn yellow early in the growing season, and the crowns are thin. Trees that survive a first attack may become reinfested and die later. A few trees seem to be resistant to scale infestation.

***Nectria* sexual stage** ▶



▼ **Yellow foliage of infected tree**

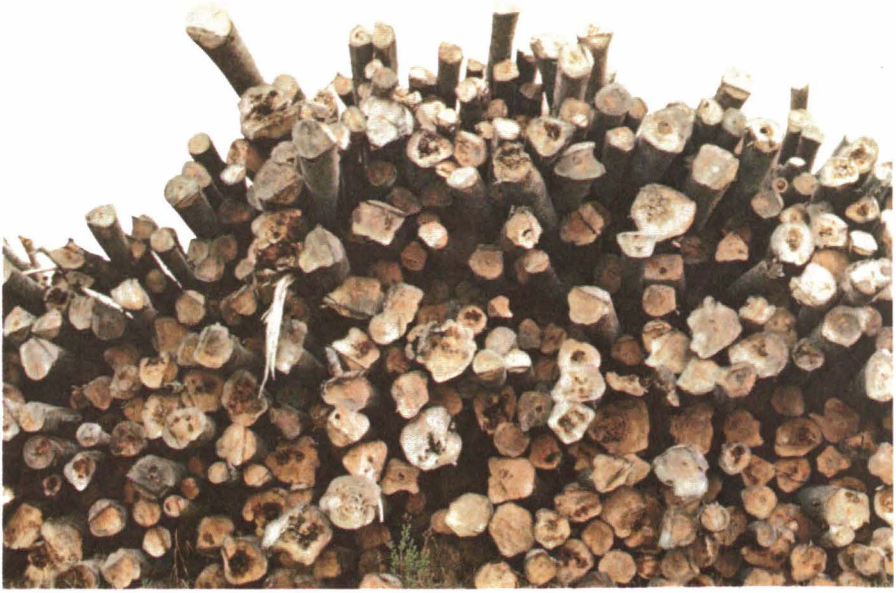


TRUNK DECAYS

All tree species are susceptible to attack by decay fungi. Spores of these fungi are released constantly into the air from reproductive structures (conks) present on already infected and decayed trees. When the humidity and air temperature are suitable, the fungi can enter the tree through such openings as dead branches or branch stubs, fire or insect injuries, and mechanical wounds caused by loggers or recreationists.

After a tree is wounded, the time required for the wood to discolor and decay varies considerably. The presence of a conk usually indicates that tissue deterioration is quite advanced. The percentage of the tree affected varies with the fungus species and, of course, with the time the fungus has had to act. Trees resist fungal invasion by "walling off" an infection. Barriers or "walls" are formed, or already exist, on all sides of an injury. The barriers above and below the wound are the weakest. Therefore, the tree decays up and down more rapidly than to either side or toward the inside or outside of the tree. The strongest barrier forms toward the outside of the tree as the entire cambium reacts to the injury. This barrier confines decay to "old" wood, that is, the wood formed before injury. Unless the tree is wounded again, or unless the fungus itself can re-wound the tree and bypass this barrier (as the "canker rot" fungus *Inonotus obliquus* readily does), the wood formed in the years after injury is sound. Because of the resistance of the strongest "wall," a tree's trunk may be a tube of sound wood with the center of the tree completely decayed.

Recent botanical discoveries have led to reclassification of many of the rot fungi, and therefore, the names have been changed. In this publication the old names are in parentheses following the new ones. Most of the decay fungi discussed cause significant timber loss or degrade.



▲ **Exposed trunk decay on cut trees**

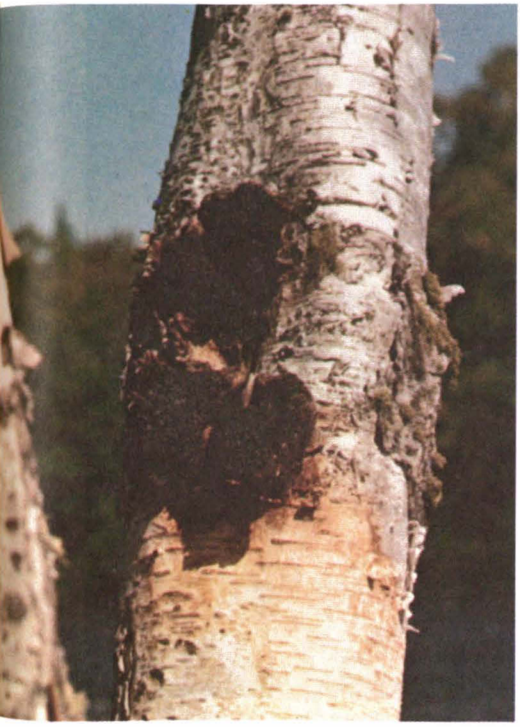
WHITE TRUNK ROT OF BIRCH (A)

Inonotus obliquus (formerly *Poria obliqua*) causes a trunk rot of both yellow and paper birch. The fungus enters the tree through wounds, especially poorly healed branch stubs. Once the fungus is in the tree, decay is rapid and extensive. A tree with the typical "cinder conk" (a mass of black tissue that forms in openings on the trunk) is usually 50 to 100 percent cull. Other apparently healthy trees in the same stand may also be badly decayed. Viewed at the end of a cut log, decayed wood is yellow with a dark brown border.

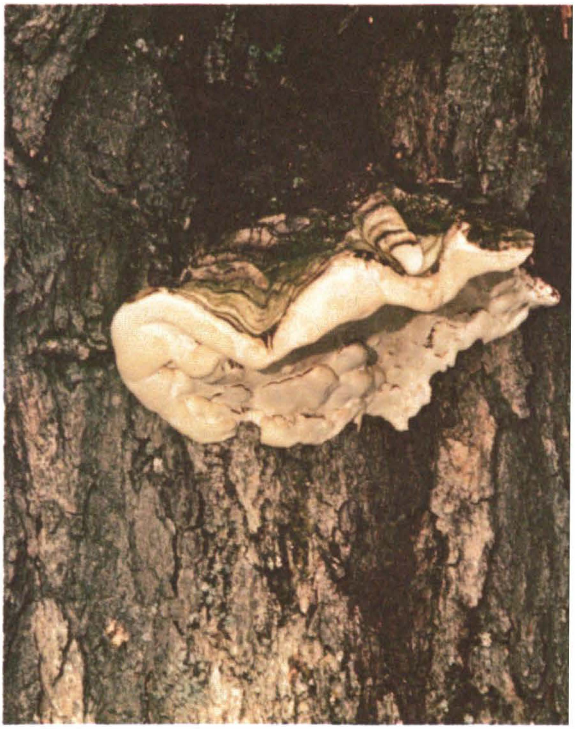
The "cinder conk" is not a fruiting body, but a wedge. The structure forces the bark apart, keeping the wound open and allowing the fungus to enter uninfected wood. Every time the tree walls off the fungus, the wedge kills additional tissue; the fungus continues to infect, and a canker forms. Perhaps 6 years after a tree has died and decay has spread throughout the wood to the bark, the fungus fruits. The inconspicuous and short-lived fruiting bodies form under the bark and break through. They are flat, thin, and brown in color.

OXYPOROUS POPULINUS (B)

Oxyporus populinus (formerly *Fomes connatus*), found most commonly on maple and beech trees, is associated with wounds on the lower portion of the tree (below 8 feet). The fruiting structure is usually a small, whitish conk often covered with green moss. It causes a dark, wet, spongy decay that ends a short distance from the wound.



▲ **Sterile conk on birch (A)**



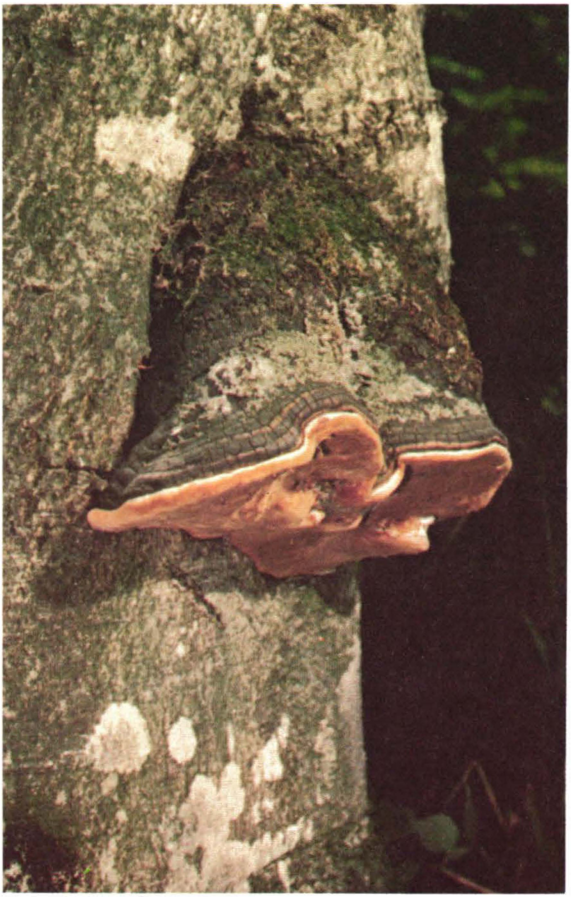
▲ **Conk on maple (B)**

PHELLINUS IGNIARIUS AND P. TREMULAE (A)

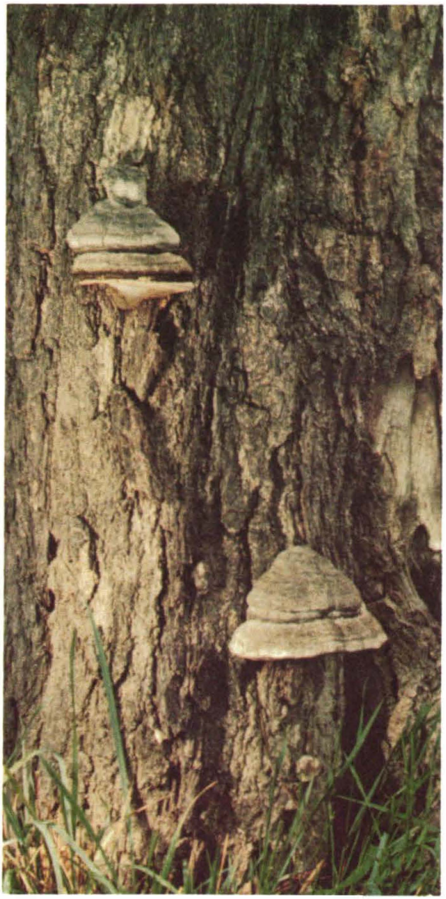
Phellinus igniarius (formerly *Fomes igniarius*) attacks most hardwoods, but prefers beech, birch, and aspen. A closely related fungus, *P. tremulae* (formerly *Fomes igniarius* var. *populinus*), causes more volume loss in aspen than any other trunk rot. The conks of both fungi are black and rough on top and may be shaped like a horse's hoof. A cross section shows several distinct layers of dark-brown pores, some of which may be filled with white, fluffy mycelia. Wood decayed by these fungi is low in density and a pale yellowish-white. Dark zone lines may form at the outer boundaries of the decay.

FOMES FOMENTARIUS (B)

Fomes fomentarius affects many hardwoods but prefers beech, birch, and aspen. Decay usually is limited to areas killed by some other agent. The conk is hard, gray, smooth, and shaped like a horse's hoof. The conk is similar to that of *Phellinus tremulae* and *P. igniarius*. The wood decayed by *F. fomentarius* is soft, spongy, and yellowish white.



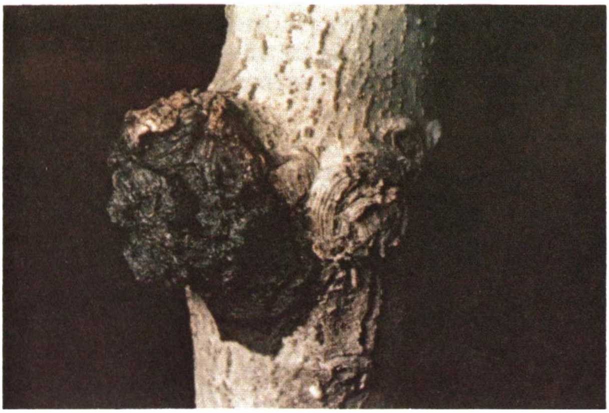
▲ **Conk (A)**



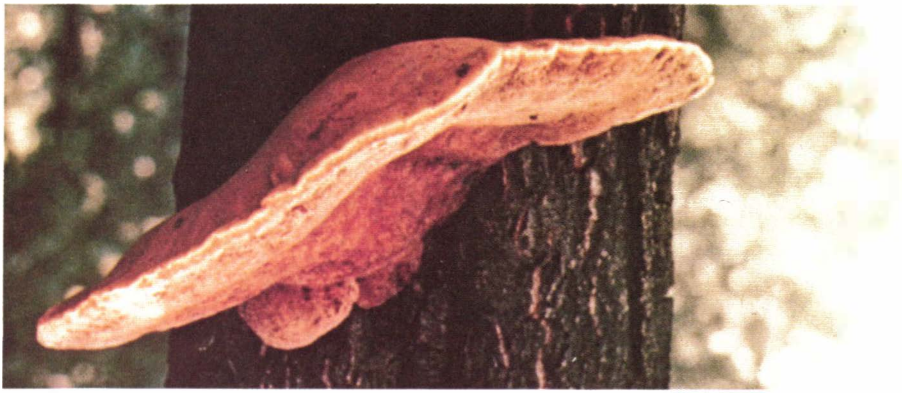
▲ **Conks on trunk (B)**

INONOTUS GLOMERATUS

Inonotus glomeratus (formerly *Polyporus glomeratus*) is an important decay organism of sugar maple, red maple, and beech. A black, cinder-like mass of fungal material forms in the opening created by a dead branch stub. This material is sterile, similar to that formed by *I. obliquus*. *I. glomeratus* causes a canker rot on its host just as *I. obliquus* does on birch. Rot is usually extensive, and the decay is greater in the upper portions of the tree above the branch stubs. The yellowish-brown conks form on the undersides of down trees or logs.



▲ **Sterile conk**



▲ **Conk**

INONOTUS HISPIDUS

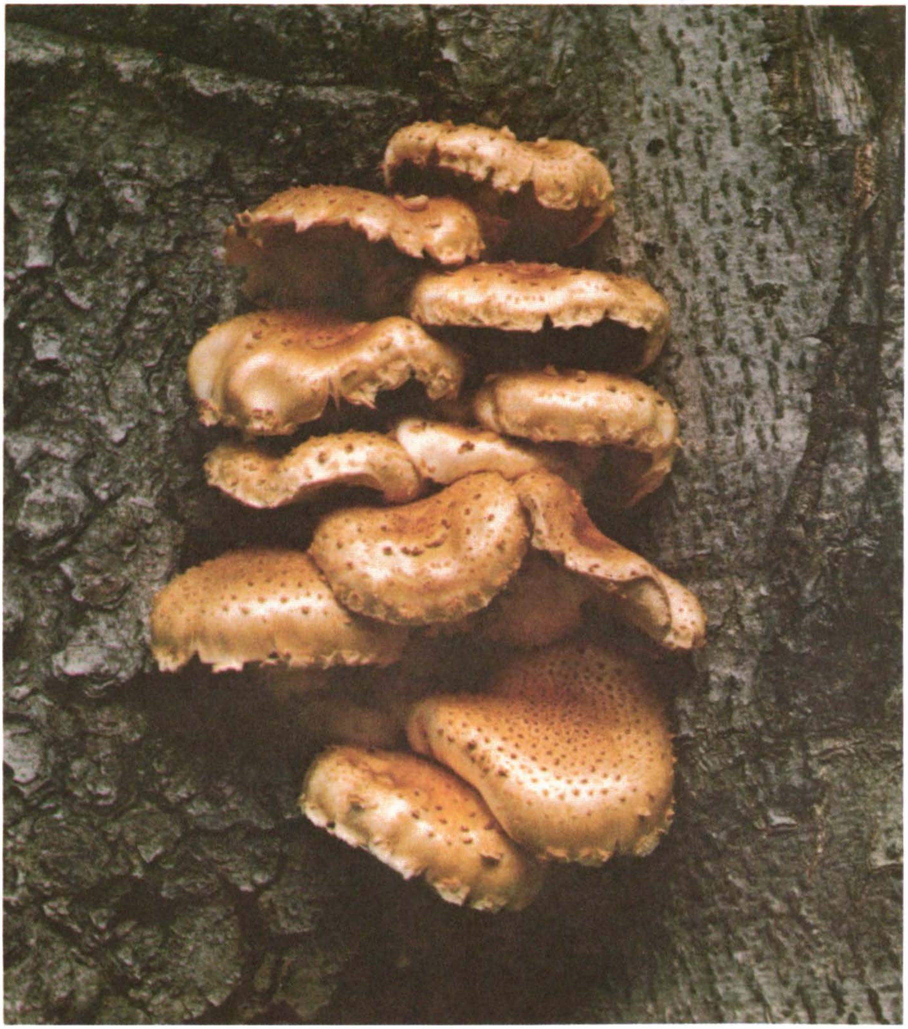
Inonotus hispidus (formerly *Polyporus hispidus*) causes localized defect in black ash and oak. Because this fungus is associated with branch stubs, frost cracks, or other wounds, the decay is mostly in the upper portion of the trunk. In southern oaks the fungus also commonly causes a canker rot. The rotting wood becomes yellowish-white and spongy. The conk is shelf-like and up to 10 inches wide. The undersurface is golden brown. The conk is an annual, formed in the fall and borne for only a few months.

PHOLIOTA SPP.

Fungi of the genus *Pholiota* attack hardwoods and some conifers. They are among the major decay fungi but often are overlooked because the fruiting bodies last only a short time. Basswood, birches, poplars, and balsam fir are common hosts.

The conks are yellow or light-tan mushrooms that appear in late summer on decaying trunks, stumps and logs. The mushrooms appear in clusters and have caps with sticky upper surfaces, scales on both caps and stems, and gills beneath the caps.

In conifers, advanced decay has a mottled appearance — dark-brown streaks on yellow areas. If the wood is split along the grain, strands of mycelium may pull out, leaving pits in the wood. In hardwoods, decayed wood is whitish with tannish-brown streaks and white patches that become yellowish to rusty-red or brown.



▲ **Mushrooms on trunk**

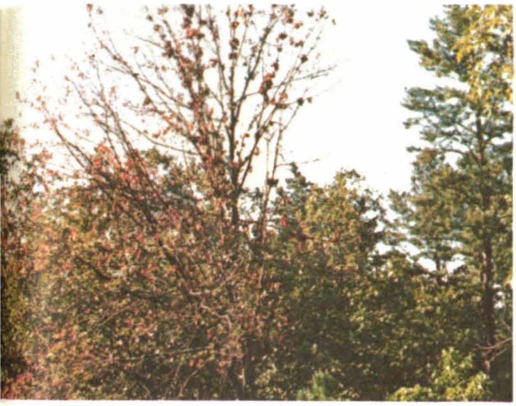
OAK WILT

Oak wilt, caused by the fungus *Ceratocystis fagacearum*, has been reported from the Lake States east to Pennsylvania and south to Texas. All oak species are susceptible to the fungus. Red oaks are more susceptible than white oaks and may die within a month after infection. Symptoms first appear at the top of the tree and progress downward. In the white oaks, a few branches usually die each growing season for several years.

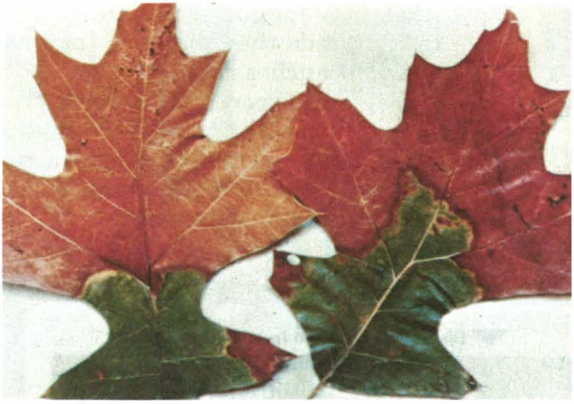
Symptoms may appear any time during the growing season, but usually appear in early summer. Premature dropping of the leaves is a common first symptom of oak wilt, but in the Lake States, infected trees often retain their leaves. The leaves usually crinkle and develop a black stem and a sharp line between green and brown leaf tissue. Some fallen leaves may be green toward the center and brown near the edges. Others may remain entirely green.

The fungus fruits asexually within the vessels of the tree, and the spores are carried throughout the tree in the transport system. Sexual fruiting bodies form in pads of black fungal material beneath the bark, causing breaks in the bark. The spores are sticky and cannot be blown to new hosts. Oak wilt is spread locally through root grafts with adjoining trees, and over long distances mostly by insects. Because some of these insects feed on sap that flows from wounds, wounded oaks are especially vulnerable.

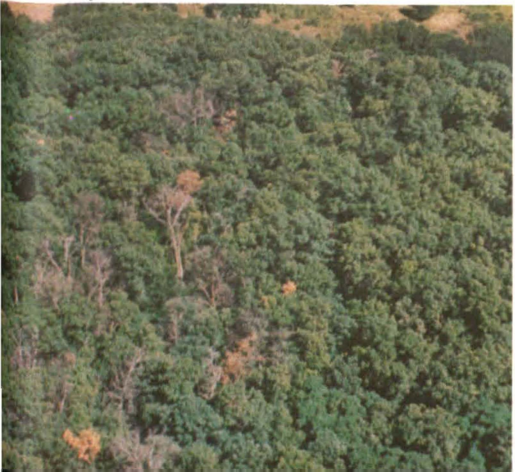
▼ Wilt-killed red oaks



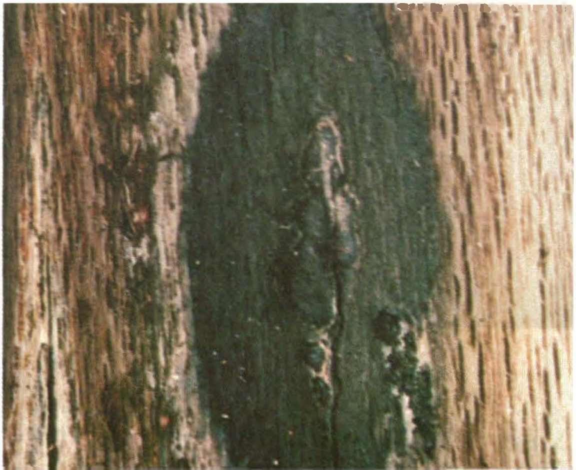
▼ Leaves from an infected red oak



▼ "Pocket" of dead and dying trees



▼ Fungus pad bearing sexual fruiting bodies



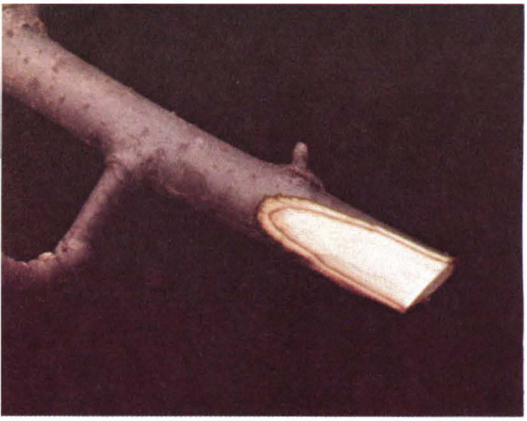
DUTCH ELM DISEASE

Dutch elm disease, caused by the fungus *Ceratocystis ulmi*, affects all elm species, although Asiatic elms are somewhat resistant. American elm is more susceptible than the other native or European species. Dutch elm disease causes a wilting or shriveling and drying out of the leaves and shoots. Affected branches are killed quickly and the leaves drop. One or more branches may be affected, or disease symptoms may develop throughout the entire crown at once. Infected trees usually die within a few weeks, but some die slowly, branch by branch, over a period of years. Inside the bark of affected trees, the outer layer of wood becomes mottled, streaked, or uniformly discolored. A cross section of the stem reveals brown spots or a dark outer annual ring.

The adults of two species of elm bark beetle, the smaller European elm bark beetle, *Scolytus multistriatus*, and the native elm bark beetle, *Hylurgopinus rufipes*, carry the Dutch elm disease fungus. The introduced European elm bark beetle is a more abundant and effective carrier of the disease fungus, although the native elm bark beetle inhabits a larger area. In the United States, there are usually two beetle generations each year. Beetles lay eggs either in weakened living trees or in dead elm wood with bark that is still tight and uncracked. The larvae feed just beneath the bark.

The fungus and the beetles (larvae) both overwinter in weakened and dead elm. In spring the adult beetles emerge from the wood, often with the sticky fungus spores clinging to them. The beetles introduce fungus into wounds they make as they feed in twig crotches or on the bark of young branches of healthy trees. The fungus soon fruits within the tree's vessels, and spores are carried rapidly by the tree's transport system to other parts of the tree. The fungus also can be spread through root grafts between an infected tree and an adjacent healthy one. Elm trees infected in the spring or early summer usually die within a few weeks. Those infected in late summer may not die until they begin to leaf out the next spring.

▼ Discolored sapwood from diseased tree



Diseased tree ▶

ELM PHLOEM NECROSIS

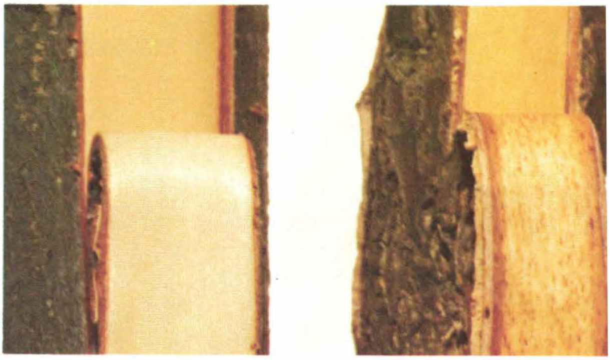
Elm phloem necrosis is caused by a mycoplasma-like organism transmitted by the whitebanded elm leafhopper, *Scaphoideus luteolus*. The disease affects American elm and its varieties, slippery elm, winged elm, and Buisman elm. Siberian and Scotch elm seem resistant.

The small fibrous roots die before any symptoms appear in the crown. Even the larger roots often are dying and the lower part of the stem becoming discolored by the time the leaves show symptoms. The first foliage symptoms are drooping leaf blades and upward-curling leaf margins. The leaves then turn yellow or brown, or both, and fall from the tree. Usually all branches on a tree show symptoms at the same time, but sometimes the symptoms develop branch by branch. American elms usually die within a year after symptoms appear. Slippery elms normally survive for at least 2 years and usually develop witches' brooms before dying.

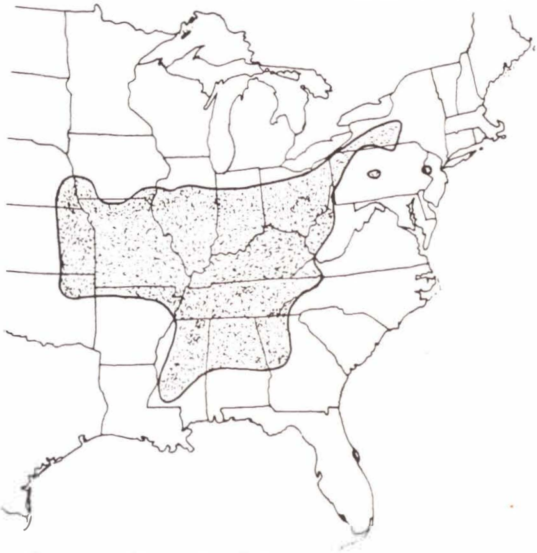
The inner bark of large roots and the lower trunk of affected American elms is a yellow to butterscotch color, and has a wintergreen odor when freshly peeled. The odor can be detected after the bark sample has been in a warm, stoppered vial for a few minutes. The dead tissue of infected slippery elm sometimes has an odor similar to that of maple syrup.

Photo credit: Cornell Univ.

▲ Diseased tree



▼ Healthy (L) and diseased (R) stems ▼

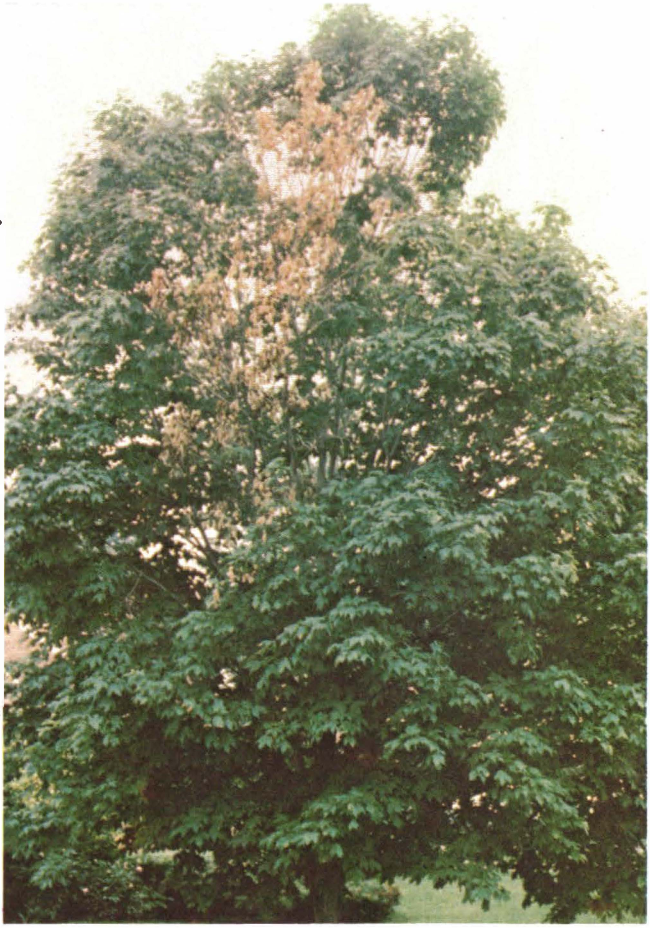


Distribution of phloem necrosis (1977)

VERTICILLIUM WILT

Verticillium wilt, caused by the fungus *Verticillium albo-atrum*, affects many genera of trees and shrubs, especially maple. Foliage of affected trees may wilt at any time during the growing season. Sometimes only a few branches wilt, sometimes a whole section of crown, and sometimes the entire crown. If all branches are affected, the tree dies rapidly. Some trees that show a small amount of wilt may recover and not show wilt in following years. Drought or insect attacks increase wilting and hasten death of infected trees.

The Verticillium wilt fungus is soil-borne and can persist many years in soil without host plants. The fungus infects trees through root and stem wounds and may be carried from infected to healthy trees on pruning tools. The fungus fruits and spreads throughout the tree in the water-conducting vessels of the sapwood. The vessels become discolored after the fungus reaches them, as does the springwood of the current year's growth. In stem cross sections, discoloration is seen as spots or as partial-to-complete rings involving one or more annual growth rings. In wilting trees the discolored streaks in the sapwood may be limited to the trunk, extend only a few inches into the basal portion of wilting branches, or extend to the tips of wilting branches.



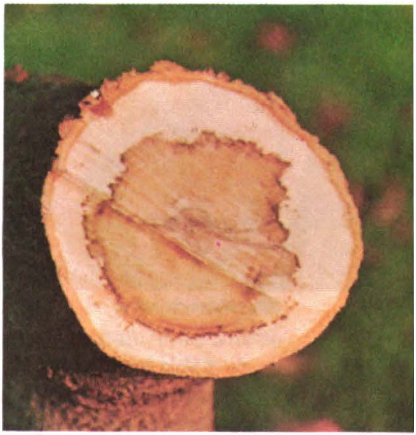
Infected tree ▶

SAPSTREAK DISEASE OF SUGAR MAPLE

Sapstreak disease of sugar maple, caused by the fungus *Ceratocystis coerulescens*, is uncommon. The disease has been found in only a few localities in Michigan, North Carolina, Vermont, and Wisconsin. However, the disease is lethal and will become important if it becomes widespread. Only sugar maple is known to be affected, but yellow-poplar is susceptible to a strain of *C. coerulescens*.

Sapstreak in sugar maple first causes a dwarfing of the leaves in all or a portion of the crown. Over the next several years, the tree gradually declines: the leaves become more dwarfed, the condition spreads to all portions of the crown, and twigs and branches often die back. After 3 or 4 years, the tree dies. As crown symptoms develop, the wood, usually only in the lower stem and roots, becomes stained. A cross section of the stem usually shows a radiating pattern of dull gray or brown stain with green outer tips.

C. coerulescens often grows as a saprophyte on recently killed or cut wood. The fungus produces both sexual and asexual spores. The spores, like the spores of other species of *Ceratocystis*, are sticky and are spread by insects or other animals. Wounds caused by logging are the most common entry points for the fungus.



▲ **Cross section of infected stem**

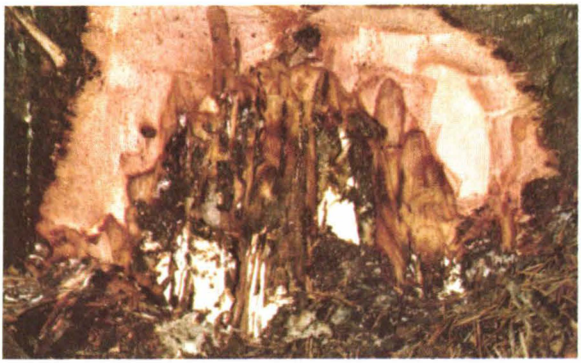
◀ **Diseased tree**

SHOESTRING ROOT ROT

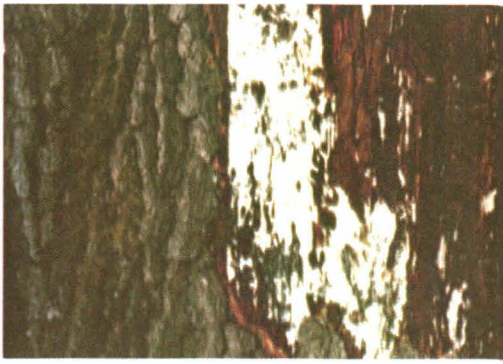
Armillariella mellea (formerly *Armillaria mellea*), the cause of shoestring root rot, often kills trees previously stressed by drought, insects, other pathogens, or unfavorable environment. However, under some circumstances the fungus, or certain strains of the fungus, can kill vigorous trees. Both hardwoods and conifers are attacked.

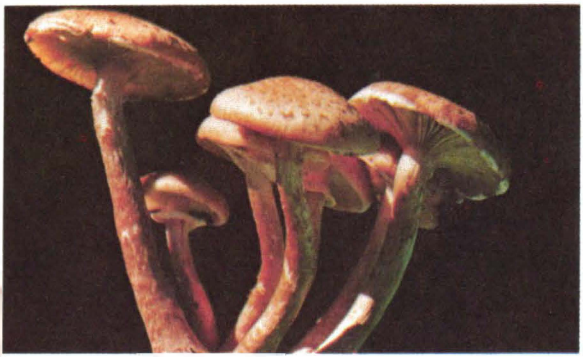
The symptoms are similar to those caused by other root-rotting organisms. The leaves or needles may become yellow or smaller than normal, the crown may become thin, and branches may die one at a time as the tree gradually declines. Often, however, death is sudden. Trees may die singly or in groups. Infected conifers often produce resin at their bases. Infected hardwoods may appear healthy except for a cracking or splitting of the bark near the ground line. White fans of fungal tissue are produced under the bark, usually at root collar level, although they may extend up to 6 feet or more. Honey-colored mushrooms with yellowish-white gills on the undersurface are sometimes produced at the base of the tree in the fall. Black shoestring-like structures (rhizomorphs) may be found around the roots and in the soil.

▼ **Infected conifer with basal resinosus and mycelial fans**

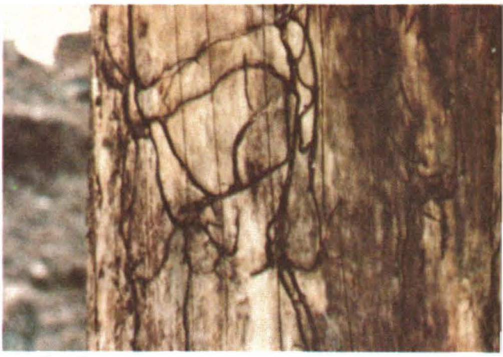


▼ **Mycelial fans**





▲ **Mushrooms**



▲ **Rhizomorphs**

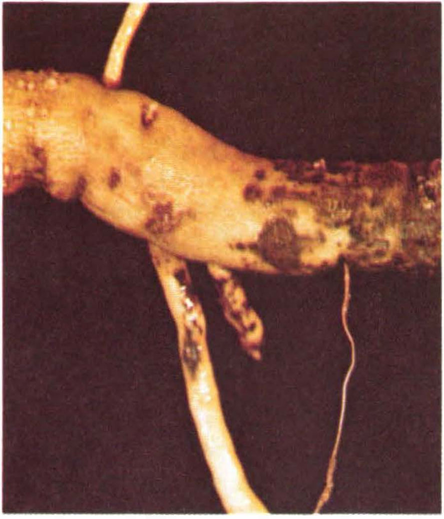
Armillariella spores can germinate on dead wood, and the fungus acts as a wood rotter. Live roots become infected when they come in contact with decaying wood or the rhizomorphs. The rhizomorphs may grow out for several feet through the soil from a large food source, such as an old stump. Young pines planted on an area from which hardwoods have been logged are especially likely to be killed. The soil can remain infested for many years.

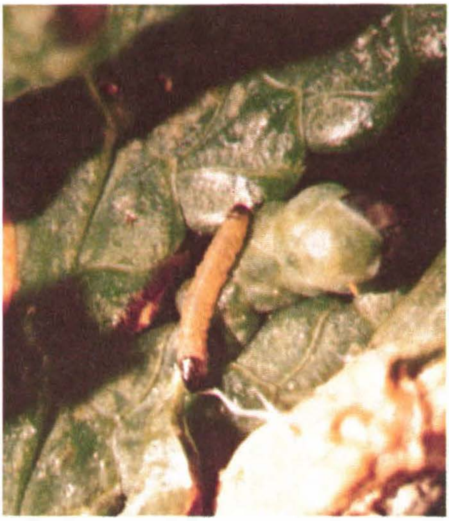
CYLINDROCLADIUM ROOT ROT

Root rot caused by several species of *Cylindrocladium* has been found in many tree nurseries in the Lake States and in eastern and southeastern United States. The preferred hosts of these soil-borne fungi are eastern white, red, and Scots pines, Norway and white spruces, eastern hemlock, black walnut, and yellow-poplar. Austrian pine, sweetgum, oak, and most of the southern pines are attacked also.

The fungi overwinter as hardy "resting" spores and attack young, newly planted seedlings. *Cylindrocladium* may kill seedlings as they sprout from seed or cause root rot in young seedlings. When conifers are attacked, the foliage shrivels and turns red. The foliage of hardwoods turns yellow and then a reddish brown. The roots of both conifer and hardwood seedlings will turn black when infected, and the outer bark will loosen and crack.

▼ **Infected root**





▲ **Larva**

ARBORVITAE LEAFMINER *Argyresthia thuiella*

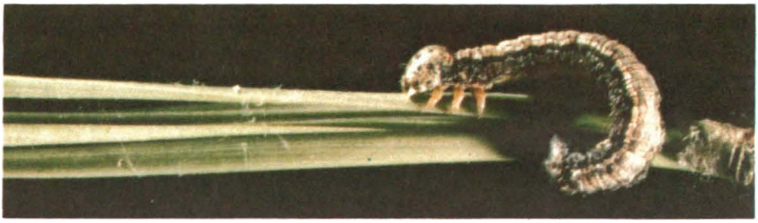
This insect mines the scale-like leaves of northern white cedar (arborvitae). As the larvae feed on and excavate the tissue between leaf surfaces, individual leaves or groups of leaves at the tips of branches become yellow or brown. Leafminer injury can be distiguished from browning due to other causes by holding a leaf to the light; with leafminer injury, the leaf will appear translucent. The larvae themselves may be seen in the mines in late summer or early spring by holding a leaf to the light and probing the brownish area to make the caterpillars wiggle. The mined leaves give the tree a sickly and unsightly appearance; the greatest damage is to ornamental plantings.

Arborvitae leafminers overwinter as immature larvae in the leaves. In late April and early May the larvae are feeding, and pupation occurs in May. The adult moths, which appear from mid-May through June, are light gray, with an average wingspan of ⅜ inch. They wedge their eggs between the tip of one leaf scale and the base of an adjoining one. On hatching, larvae enter the leaf. Most moths have laid their eggs and died by July 1. There is one generation per year.

PITCH PINE LOOPER *Lambdina athasaria pellucidaria*

The pitch pine looper is a native insect that causes considerable damage to foliage of pitch, red, and Virginia pines, and possibly others. These loopers differ from most in that they feed singly on needles instead of in colonies, and that they chew out only a portion of each needle. Injured needles turn brown and, if the infestation is heavy and persists for 2 or 3 years, serious tree injury and mortality may occur.

Larva ▶

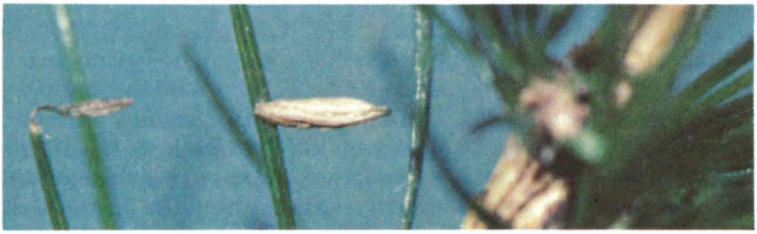


Pupae overwinter in the duff beneath the trees. In May or June the moths emerge and lay shiny, pale-green eggs on both sides of the needles. After the eggs hatch, the loopers feed on the needles until late September. They develop much more slowly than most caterpillars. Full-grown loopers average 1 to 1½ inches in length. They have pale-straw to greenish-yellow bodies, with black markings on their sides and black dots on their backs. Their heads are marked with dark and light brown spots. Because they vary considerably in color, positively identifying them is difficult. Probably the best way to identify them in the field is to determine whether the pine needles were mined or eaten completely. After they are full grown, the larvae drop to the ground and pupate. There is one generation per year.

LARCH CASEBEARER *Coleophora laricella*

The larch casebearer defoliates all native and introduced species of larch. First reported in Massachusetts in 1886, it has spread across the northern states throughout most of the range of larch. Feeding begins on new foliage in early spring, often allowing refoliation in the same season. Needles not completely consumed turn red. Growth reduction can follow a single defoliation, and trees die after two or more severe defoliations.

Larval case ▶

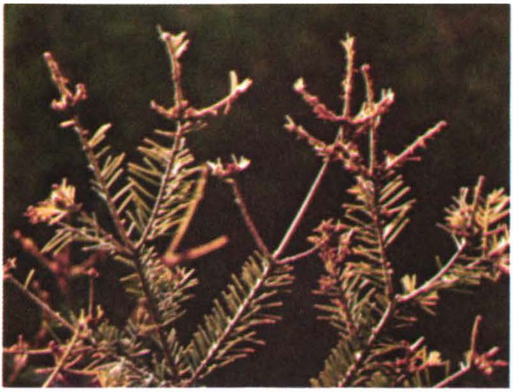


Eggs are deposited on the undersides of needles. Larvae feed as needle miners, and in late summer form cases within the mined needles. Before winter, casebearer larvae migrate to an outer twig or branch; they fasten their cases to the branch and overwinter. Larval cases, which help identify this insect, are most obvious after normal needle drop in the fall or winter. Pupation occurs after the fourth instar, and moths are present from late May until early July. There is one generation per year.

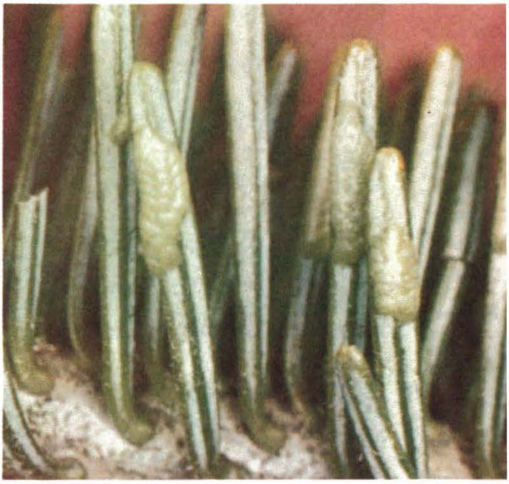
SPRUCE BUDWORM *Choristoneura fumiferana*

The spruce budworm prefers to feed on balsam fir, although white, red, and black spruce are also suitable hosts. Occasionally, heavy feeding occurs on hemlock, pine, and larch.

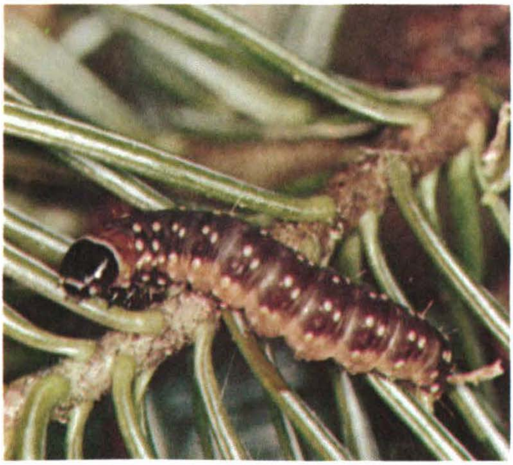
After overwintering under the bark scales of host trees, budworm caterpillars emerge in spring to mine flower buds and older needles. As they grow older and larger, they move to the ends of branches and bore into vegetative buds. Later they become free feeders, preferring new foliage. At this time the 1-inch black-headed caterpillars are dark brown with light dots along their backs. Pupation occurs from mid-July to early August, usually at twig crotches or in webbing near branch tips. Pupae are reddish to light brown with darker bands and spots. After about 12 days, the adult moths emerge. Grayish with dark-brown markings, they have a wingspan of ¾ inch. Occasionally this color pattern is reversed. Female moths lay light-green eggs on the flat surfaces of fir and spruce needles near the tips of branches in July and August. Eggs are laid in masses of about 20, with the eggs overlapping like shingles. Each female lays about 200 eggs. Eggs hatch within 8 to 12 days, and the small caterpillars disperse on the branches, where they molt once before hibernating. Spruce budworms produce one generation per year in the eastern United States.



◀ **Defoliation**



▲ **Egg masses**



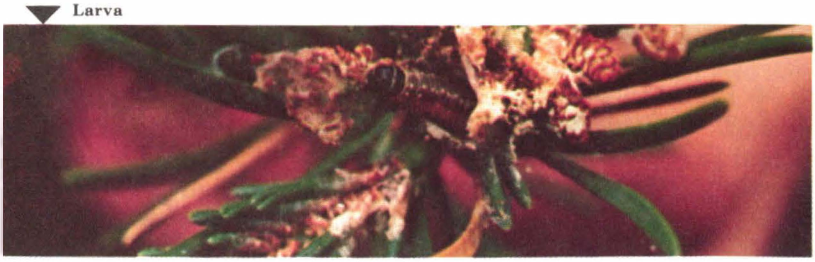
◀ **Larva**

JACK PINE BUDWORM *Choristoneura pinus*

Outbreaks of this budworm in the Lake States and adjacent Canada occur in stands predominated by jack pine, although Scots, red, and white pines may also be attacked. Defoliation by the jack pine budworm reduces tree growth, retards regeneration, and causes tree mortality. Trees of all sizes are attacked, but trees with abundant male flowers are preferred. Symptoms are brown or red needles loosely webbed onto shoots.

Jack pine budworms overwinter as second-instar larvae in hibernacula in bark crevices of branches and twigs. Spring activity begins about the time staminate flowers, or cones, appear. Budworms feed at first on the flower cones and new needles, but later consume all the foliage. Larvae mature by the end of June, pupate, and hatch into adults early in July. Mature larvae are reddish brown with small cream-colored spots along the back. Eggs are laid in masses on the needles, and usually hatch by early August. There is one generation per year.

▼ **Larva**

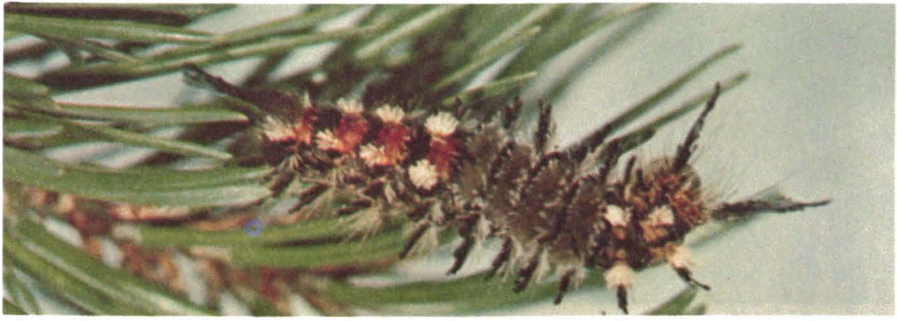


PINE TUSSOCK MOTH *Dasychira pinicola*

The pine tussock moth defoliates jack pine, red pine, white pine, and white spruce. It prefers jack pine, however, and extensive outbreaks have killed thousands of jack pine seedlings and saplings.

Pupation occurs on the host tree in a cocoon of hairs and silk, and gray-brown moths emerge in July. Small, irregular egg masses are usually deposited near the female pupal case. During July, first- and second-instar larvae feed on needles. When populations are abundant, the larvae mature and feed on old needles down to the needle sheath. The larvae are gray-brown, hairy, and have four tufts of grayish hairs on the back. Tree shoots often appear ragged after larval feeding is completed. In August, third-instar larvae hibernate in a loose webbing of silk at the base of needles or under bark flaps. In spring, they resume feeding on new needles and staminate flowers. There is one generation per year.

▼ **Larva**



PINE SAWFLIES

Pine sawflies defoliate many species of pine, causing tree or branch mortality and growth reduction. These sawflies can be classed generally as "spring" or "summer" species:

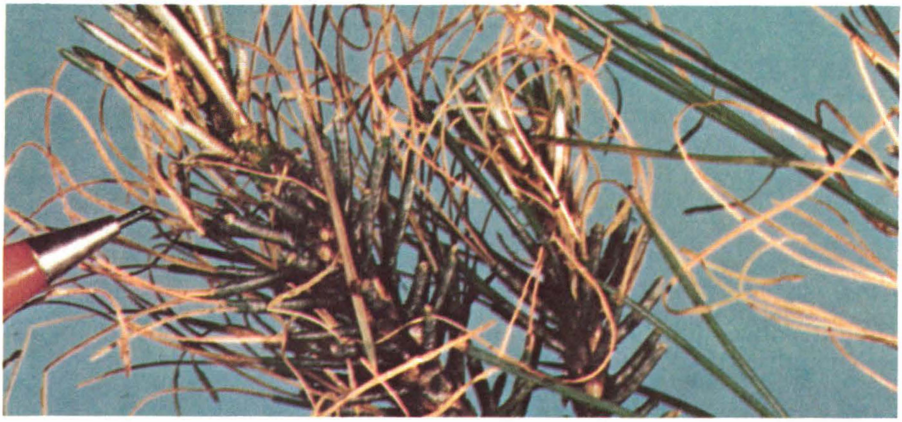
Spring Species	*Summer Species*
European pine sawfly	Introduced pine sawfly
Red pine sawfly	White pine sawfly
Jack pine sawfly	Redheaded pine sawfly
Virginia pine sawfly	

The spring species commonly feed only on old foliage, giving trees a tufted appearance with new foliage only at the branch ends. The summer species generally feed first on the current year's foliage, then attack older needles. This causes greater growth reduction and tree mortality.

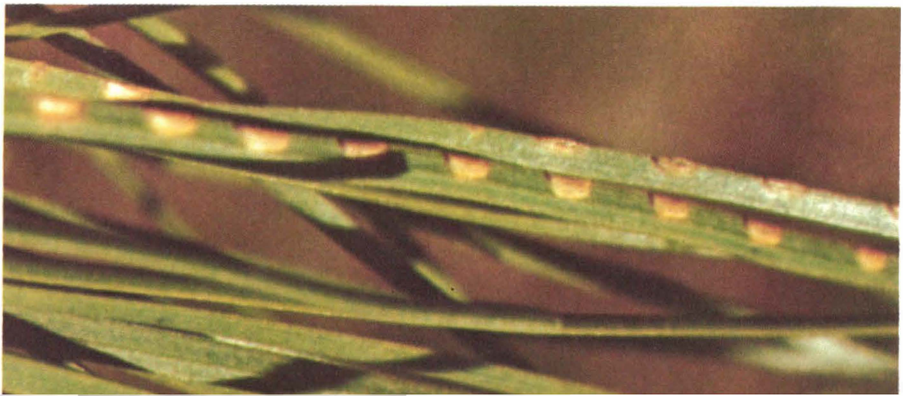
Dried, skeletonized groups of brown needles are an early symptom of sawfly infestation. These needles generally drop from the tree soon after being killed. Older larvae consume entire needles, stripping the tree branch by branch.

The life history is similar for all sawfly species. Eggs are deposited in the needles and new larvae feed in groups. Mature larvae, from ¾ to 1 inch long, form brown pupal cocoons of tough woven silk. Pupation usually occurs in the duff under the host tree, although some species may pupate on the tree. Sawflies overwinter in the prepupal stage within the cocoon, or as eggs in needles. The number of generations per year depends on species and location.

▼ **Early sawfly feeding**



▼ **Sawfly eggs**



EUROPEAN PINE SAWFLY *Neodiprion sertifer*

The European pine sawfly prefers the old foliage of Scots, red, jack, Japanese red, Table-Mountain, and mugho pines, although other pines may be defoliated when growing in mixture with these preferred species. The sawfly may also feed on tender bark, causing branch or terminal shoot deformation and occasional branch mortality. Trees of all sizes are defoliated, causing growth reduction but rarely tree mortality.

This sawfly overwinters in the egg stage; larvae emerge in mid-April to early May and begin feeding in colonies. Mature larvae have black heads and gray-green bodies with several stripes or rows of spots of varying shades of green. They pupate in cocoons in the duff or in protected places on the tree. Adults emerge in the fall and deposit eggs in slits in the needles. Eggs are seldom found on eastern white or Austrian pine, and those deposited on pitch pine do not hatch. There is one generation per year.

JACK PINE SAWFLY *Neodiprion pratti banksianae*

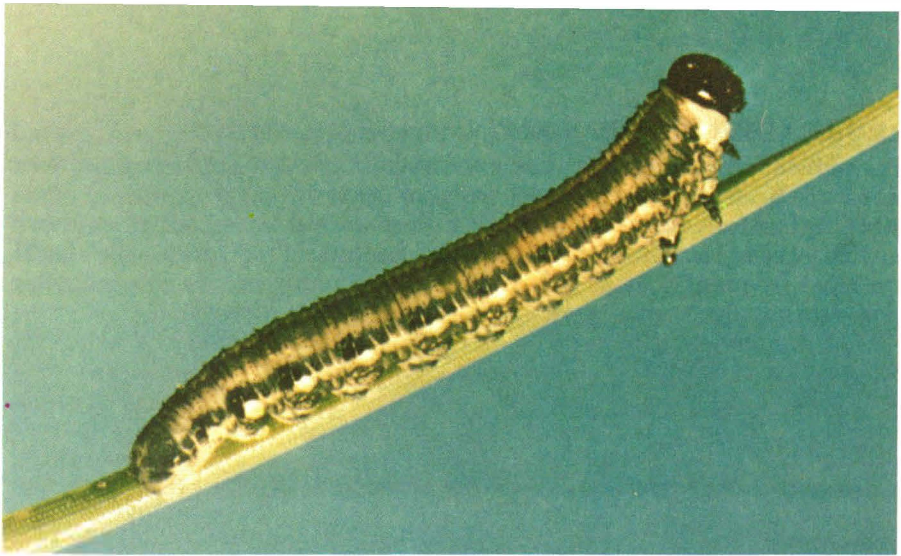
The jack pine sawfly occurs in natural stands and plantations of jack pine in the Lake States and southern Canada. Jack pine is the primary host, but red and Scots pines may also be attacked. The larvae attack old foliage on trees of all sizes, giving the trees a tufted appearance by leaving only current-season foliage at the branch tips. Defoliation results in growth reduction and some branch mortality.

The overwintering eggs, deposted in the needles, hatch in late April or early May. The larvae feed in colonies until late June or early July. The full-grown larva is yellow-green with three greenish-gray stripes (sometimes two solid stripes and one broken stripe) along the back and side of the body. The head is black. Pupation occurs in late summer, and adults lay eggs in early fall. There is one generation per year.

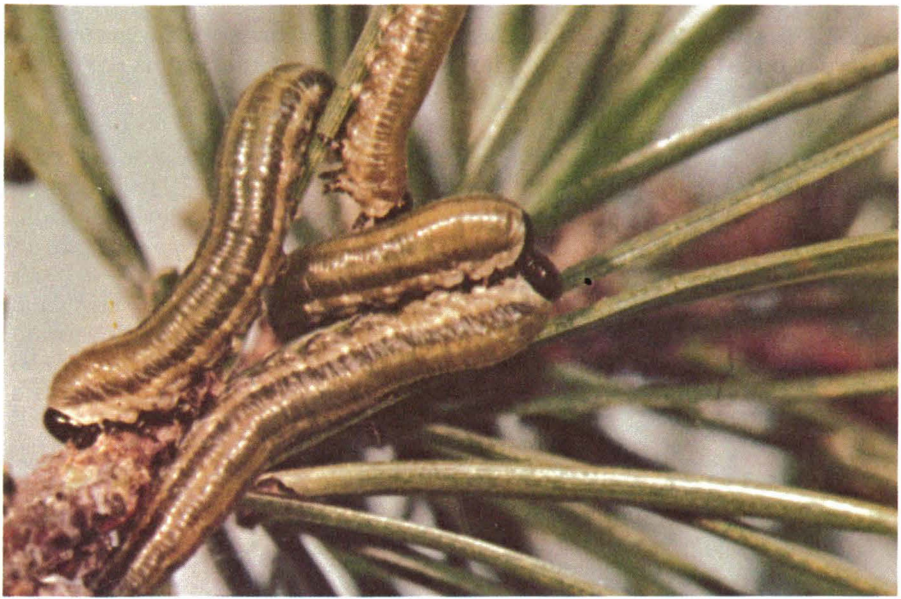
INTRODUCED PINE SAWFLY *Diprion similis*

The introduced pine sawfly prefers the foliage of white pine, although it occasionally attacks jack, red, and Scots pines as well. The first generation feeds on old foliage, while following generations consume both old and new foliage. Young larvae feed on only the tender outer parts of the needle. Mature larvae, which feed individually, consume the whole needle and also may chew on tender bark. Complete early season defoliation kills branches and entire trees.

Larvae are present from late May to early July, and again from August to September. The mature larva has a black head and a dark-brown body with a double black stripe down the back and many yellow or black spots on the sides. The first generation pupates in cocoons spun on the tree, while later generations pupate both in the duff and on the tree. Pupation is completed in early spring. Adults deposit eggs in slits cut along the edges of old needles. There is usually a second, and under favorable conditions, a partial third generation each year.

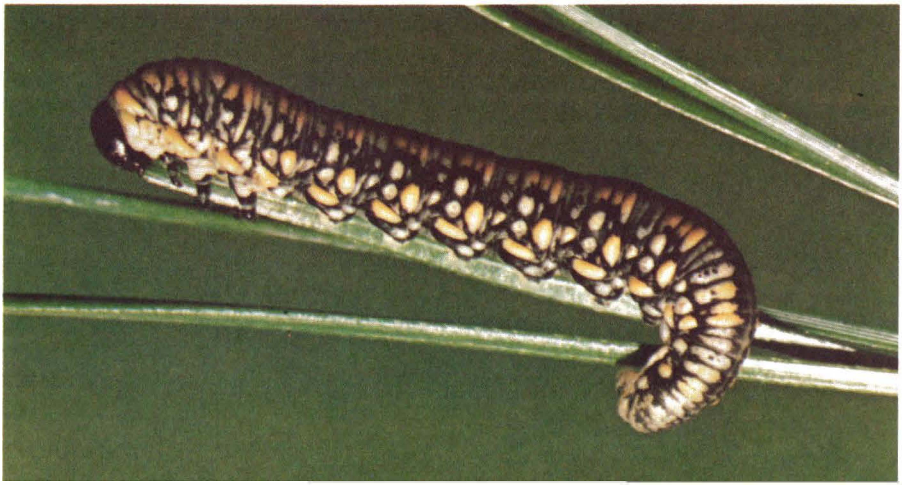


▲ Larva



▲ Larvae

▼ Larva



REDHEADED PINE SAWFLY *Neodiprion lecontei* **(A)**

The redheaded pine sawfly attacks all species of hard pines; red and jack pines are preferred in the northern portion of the insect's range, while shortleaf, loblolly, longleaf, and pitch pines are preferred in the southern portion. Trees less than 15 feet tall in plantations or windbreak stands are most frequently attacked. Mortality commonly occurs in pockets or along stand edges where trees are under additional stress.

This sawfly usually feeds on old foliage, but where more than one generation occurs, all foliage may be eaten. Thin, straw-like, brown needles, caused by the feeding of young larvae, are the first indication of an infestation. Older larvae consume entire needles as defoliation proceeds branch by branch. One complete defoliation may kill red and jack pines, while southern pines usually survive a single defoliation.

Redheaded pine sawflies overwinter as prepupae in the duff or litter layer under host trees. After a short pupation in the spring, the adults emerge and deposit eggs in needle edges. The mature larvae, which are yellowish white with reddish-brown heads and six rows of irregular black spots, feed gregariously for about a month, then drop to the ground to construct pupal cocoons. There may be one or two generations per year.

RED PINE SAWFLY *Neodiprion nanulus nanulus* **(B)**

The red pine sawfly prefers red and jack pines of all sizes, but it will also attack white, Japanese red, and mugho pines. Because only the old needles are consumed, vigorous trees are rarely killed by a single defoliation. Successive defoliations, however, can kill or reduce the growth rate of overmature trees.

This sawfly overwinters in the egg stage; larvae emerge in May, and feed in colonies during July and August. Larvae are dull grayish-green with two olive-colored stripes along the back and two dark stripes on each side; they have black heads. Pupation occurs in the duff, and adults emerge in the fall. There is one generation per year.

VIRGINIA PINE SAWFLY *Neodiprion pratti pratti* **(C)**

The Virginia pine sawfly prefers Virginia and shortleaf pines, although pitch, loblolly, jack, and red pines are also attacked wherever they occur within the sawfly's range. Severe defoliation in successive years reduces growth and weakens trees, making them susceptible to other insects and diseases.

The insect overwinters in the egg stage, and larvae emerge in April. Maturing by the time new foliage develops, the larvae have greenish bodies with black spots or lines on the sides and black heads. Feeding gives trees a tufted appearance. Mature larvae pupate in cocoons in the soil or litter. Adults emerge in late summer and deposit eggs in needles during early fall. There is one generation per year.

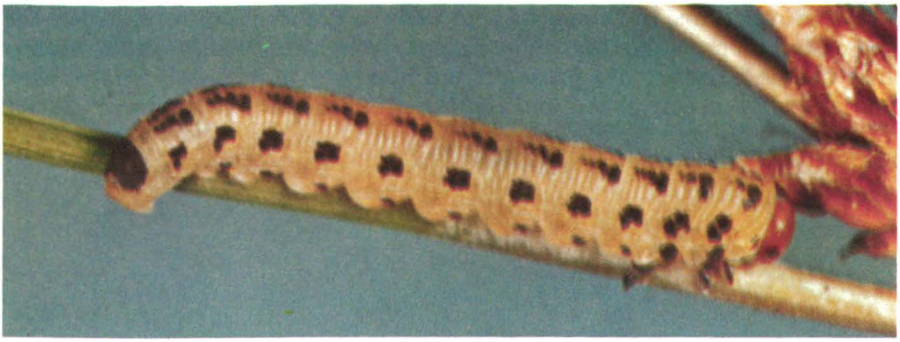
WHITE PINE SAWFLY *Neodiprion pinetum* **(D)**

The white pine sawfly prefers eastern white pine, but also attacks mugho, red, pitch, and shortleaf pines. It feeds on old and new foliage of trees of all sizes in plantations and mixed stands. Mortality can follow complete defoliation.

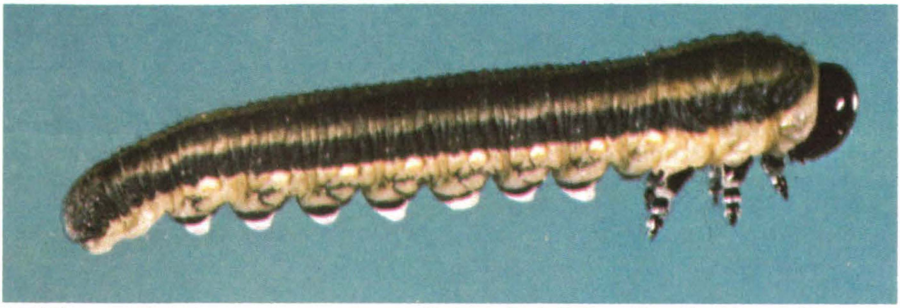
Adults emerge in spring and the females deposit eggs in the needles.

Larvae are present between mid-June and late July and sometimes for a second generation between mid-August and late September. Larvae are white with four rows of square black spots along the length of the body; their heads are black. Pupation is in the duff or soil under the host tree. There is one, and sometimes a partial second generation each year.

▼ **Larva (A)**

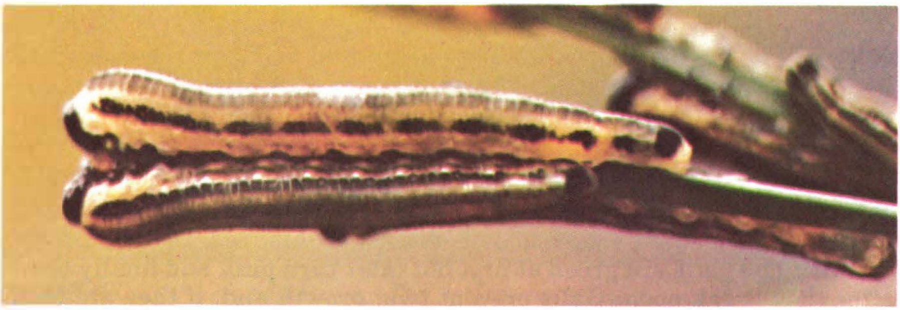


▼ **Larva (B)**



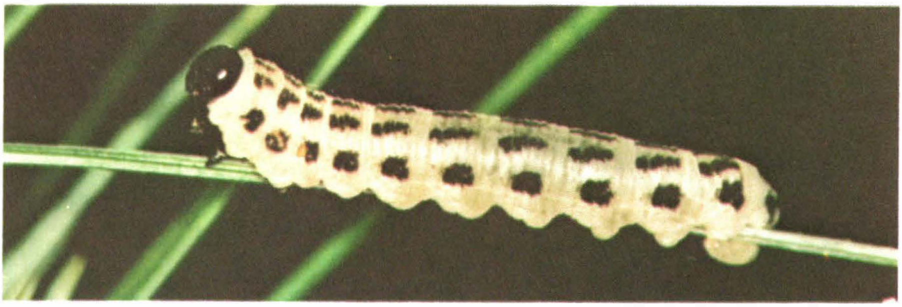
▼ **Larvae (C)**

Photo credit: A. H. Rose (Canadian Forestry Service)



▼ **Larva (D)**

Photo credit: Virginia Division of Forestry



YELLOWHEADED SPRUCE SAWFLY *Pikonema alaskensis* **(A)**

The yellowheaded spruce sawfly attacks new foliage of white, black, blue, red, Engelmann, Norway, and Sitka spruces. This sawfly is only found in the northern tier of states. Successive complete defoliations cause mortality, especially of roadside, ornamental, or young plantation trees. Stands with closed crowns are not attacked.

Pupation occurs in the spring, and adults emerge about when the bud scales fall from expanding buds. Eggs are deposited singly in the base of new needles. Larvae are present from late May to mid-July. Mature larvae are olive green above and lighter green below, with several darker stripes of variable width along the back and sides. The head is yellowish-brown and may have brown spots. When mature, the larvae migrate from the trees to the ground to hibernate in cocoons spun in the soil. There is one generation per year.

LARCH SAWFLY *Pristiphora erichsonii* **(B)**

The larch sawfly is the primary defoliating insect of native and most exotic species of larch. It attacks old foliage first, but at high population densities will completely defoliate trees. On good sites, larch trees can withstand 15 or more successive defoliations before mortality occurs. On less favorable sites, mortality may follow three or more complete defoliations.

Winter is spent in the prepupal stage. Pupation is completed in the spring, and most adults appear from mid-May to August (although some pupae may pass a second winter before emerging as adults). Sawfly eggs are deposited in the late spring in slits cut into the bark of new terminal growth. This causes the twig to curl or "pigtail," with the egg slits on the inner curve. The long adult-emergence and egg-laying period results in larvae of various sizes being present throughout most of the summer. The larvae, which are pale grayish-green with black heads, tend to feed in colonies. The larval feeding period lasts about 20 days.

When mature, the larvae drop to the ground and spin the overwintering cocoon in the duff layer. New cocoons are light brown and about ½ inch long. There is usually one generation per year.

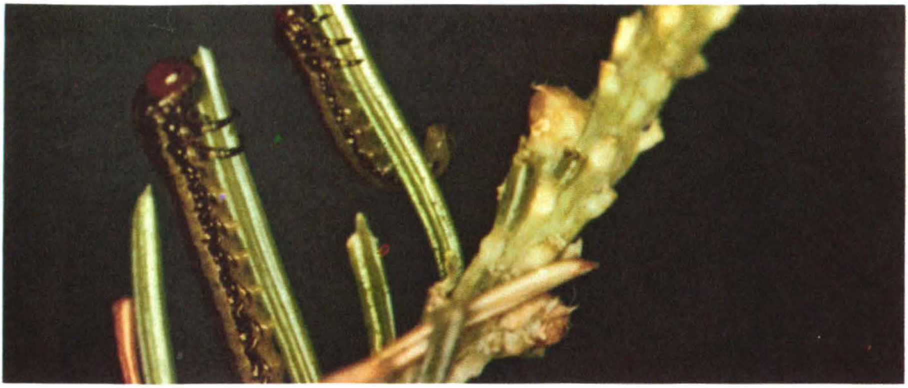
EASTERN SPRUCE GALL ADELGID *Adelges abietis* **(C)**

The eastern spruce gall adelgid, an introduced species, forms pineapple-shaped galls on the new shoots of Norway, white, red, black, and blue spruces. The galls are green at first but later turn pink and finally brown after they break open. Galls prevent twig growth and, if they are abundant, may affect entire trees. Individual trees vary in susceptibility to attack; some appear immune, others suffer growth reduction, and some are eventually killed. Trees growing on good sites are generally less susceptible to attack than those on poor sites.

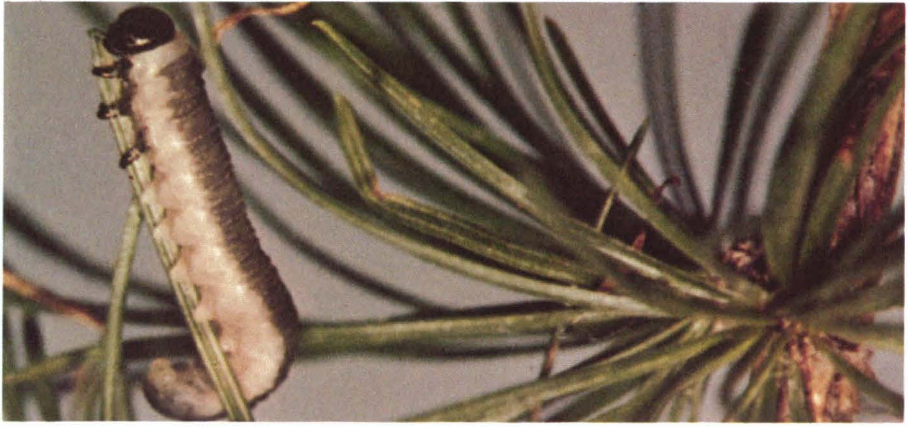
Partially grown females hibernate in twigs near the terminal buds. Pear-shaped, soft-bodied green insects with long antennae, they lack the two tube-like projections that characterize other adelgids. They mature in spring and deposit eggs at the bases of the buds. Upon hatching, the nymphs crawl to the expanding buds and begin to feed. The injection of their saliva into the plant tissues causes the cells to enlarge to form bulb-like hollows. Thousands of cells within these hollows join together to form a gall, which may contain as many as a dozen nymphs. When these galls open in midsummer, winged females emerge and fly to new needles on the same or other spruce trees to lay eggs. They die shortly afterward, leaving the eggs protected beneath their bodies, which resemble a white, cottony wax. When these eggs hatch, the immature adelgids settle at the bases of twigs to overwinter. Only females are produced.

Unlike some adelgids, the eastern spruce gall adelgid requires no alternate host to complete its life cycle. It should not be confused with the Cooley spruce gall adelgid, which forms galls near the terminal portion of twigs.

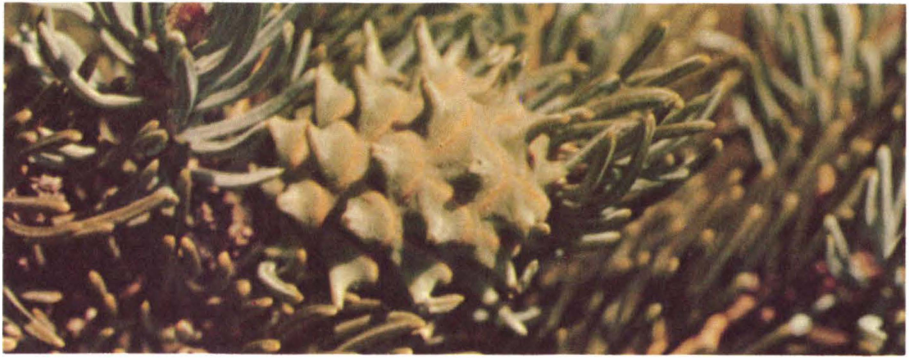
▼ **Larvae (A)**



▼ **Larva (B)**



▼ **Gall (C)**

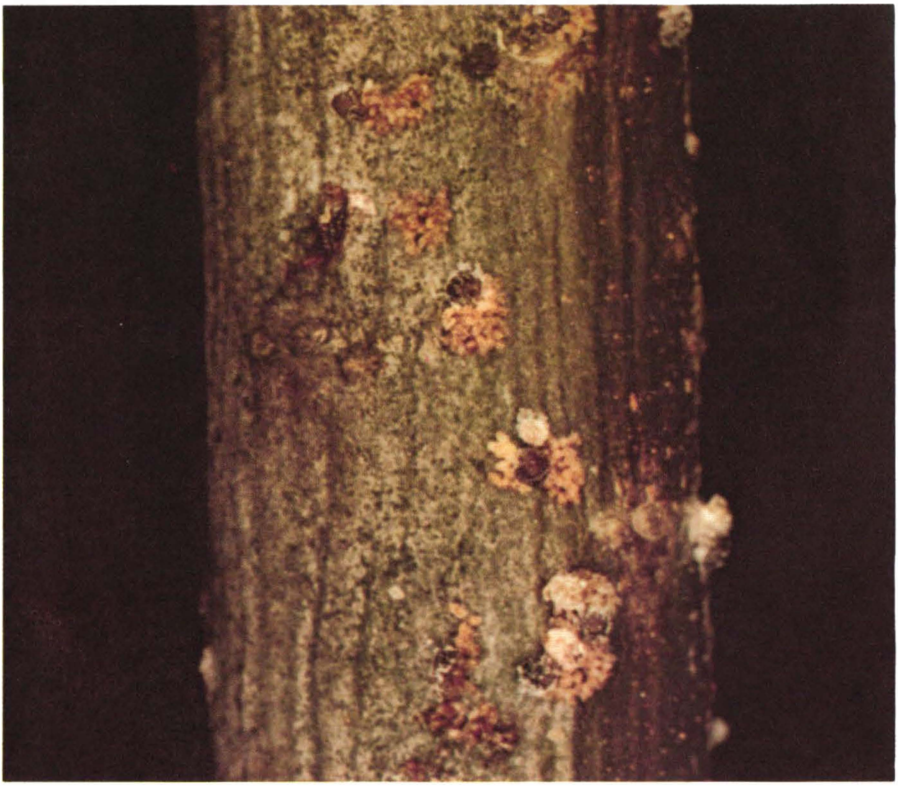


PINE LEAF ADELGID *Pineus pinifoliae*

The pine leaf adelgid is an aphid-like insect found throughout the range of white pine. It forms harmless cone-like galls on red and black spruce, which are alternate hosts. White pine is injured in alternate years; light infestations do little harm, but continued heavy attacks can cause mortality. Trees that survive heavy attacks are usually deformed.

There are four and sometimes five stages in the 2-year life cycle of this adelgid. On spruce, the insects are tiny and hidden under bud scales or within the galls. On white pine they are more readily seen. In June of odd-numbered years, the winged adults fly from spruce to white pine, where they lay eggs on the old needles, then die. Wingless nymphs emerge from these eggs, crawl to the axes of newly expanding shoots, insert their mouthparts and begin feeding. The nymphs mature in May of even-numbered years, then fly back to spruce trees where they lay eggs. The eggs on spruce trees hatch in June and the nymphs feed on sap from spruce needles. When mature, this form of the adelgid mates. The eggs produce the insects that hibernate under spruce bud scales.

▼ **Nymphal crawlers and waxy secretions**



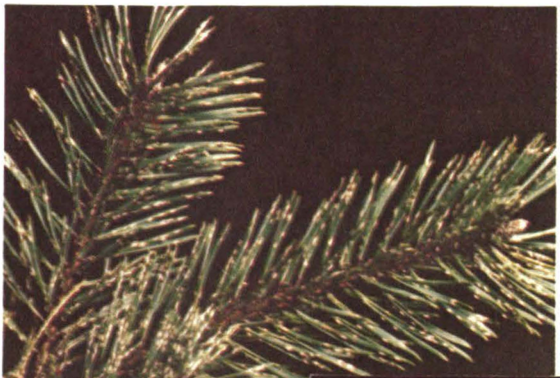
Natural factors usually keep pine leaf adelgid populations under control. Many individuals are lost during migration to pine and back to spruce. Hover fly maggots and soldier beetles destroy many of the eggs laid on white pine. Because the adelgids stay in groups, they may attack only a few shoots of a white pine tree. If there are too many insects on a shoot, they may all starve because they cannot move to another shoot.

PINE NEEDLE SCALE *Chionaspis pinifoliae*

Pine needle scale is most common on mugho and red pines, but is also found on other pine species and on spruces. This insect appears as a white, cottony speck with a yellow to orange spot at one end. The female, which is about ⅛ inch long, is twice the size of the male. In June and July, pine needle scales may be seen aligned on the needles of the host.

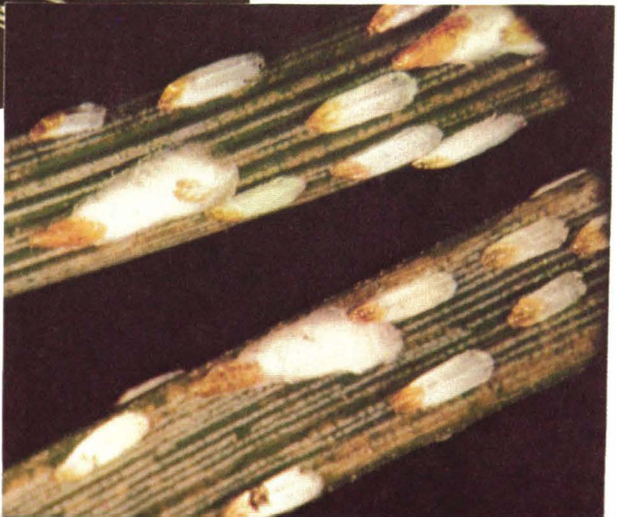
The scale overwinters as a cluster of eggs under the protective cottony covering of the female. When new tree shoots begin to elongate, the eggs hatch and the larvae crawl to new needles where they insert their mouthparts and begin to feed. The insect does not move from its feeding spot until it matures in early July. At that time, the males move about in search of females. The males, which are rare, have two wings and very soft bodies. They probably are not needed by the females for successful reproduction. A new batch of reddish eggs gives rise to the second generation. The yellowish crawlers molt twice before secreting the white covering at maturity. There are two generations per year in the South, but usually only one in the North.

Heavy infestations are rare under forest conditions, because weather and ladybird beetles usually keep populations low. Ornamental and shade trees may be killed by heavy infestations of pine needle scale, although usually a tree suffers only loss of color and growth. Newly planted trees are particularly vulnerable to this insect, which can attain outbreak proportions in a single year.



◀ **Damage and scales**

Female scales ▶

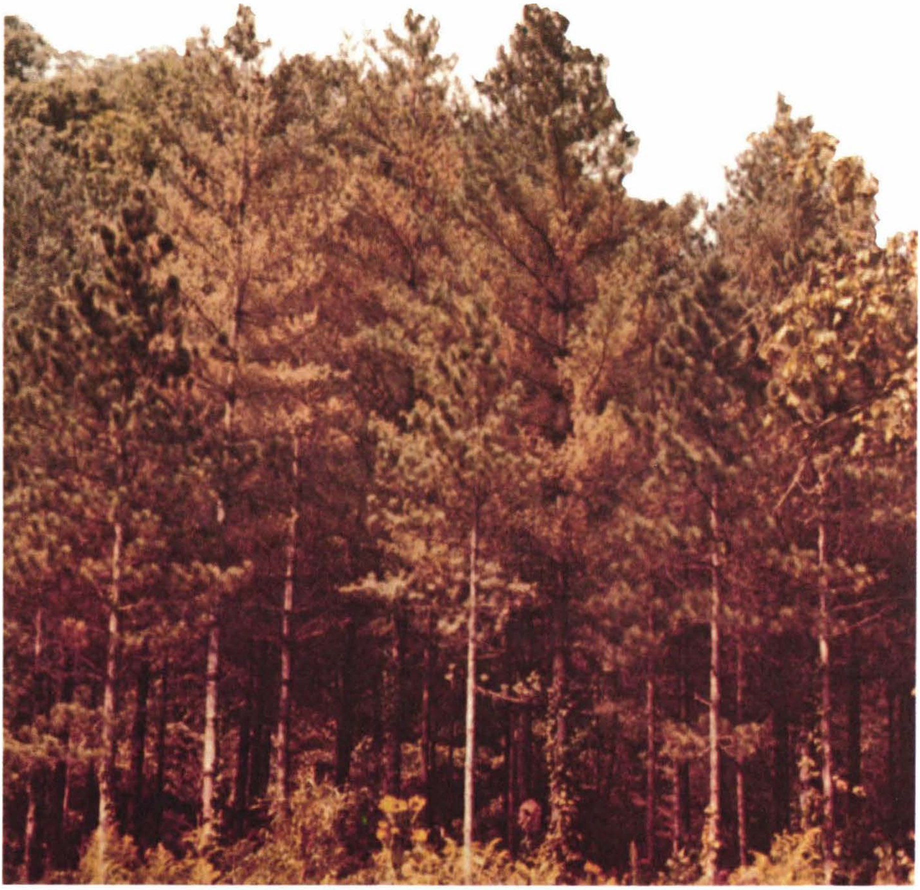


PINE BARK ADELGID *Pineus strobi*

The pine bark adelgid prefers eastern white pine, but also attacks Scots and Austrian pines. Although mature white pine trees may become unsightly when heavily infested, they seldom are damaged. However, ornamentals in park and recreation areas and also nursery stock may be injured seriously. Needles turn yellow in younger trees, and feeding damage may cause stunting or death. In older trees, large patches of white cottony material may cover the tree trunk and branches giving a whitewashed appearance.

In the spring, females lay eggs that produce both winged and wingless females. Wingless forms remain on the host tree and reproduce several times. Some of the winged forms may fly to spruce instead of white pine, where they settle on the needles, lay eggs, and die. The larvae cannot survive on spruce, however. Up to five generations have been recorded as far north as the Lake States.

▼ **Injury on white pine**



PINE BARK BEETLES

Southern Pine Beetle, *Dendroctonus frontalis*
Black Turpentine Beetle, *Dendroctonus terebrans*
Red Turpentine Beetle, *Dendroctonus valens*
Engraver Beetles, *Ips* spp.

These beetles constitute the greatest insect threat to our southern pine forests. Adults cause damage by boring into the cambium of living trees and constructing tunnels, which eventually may girdle and kill the trees.

The southern pine beetle is the most destructive bark beetle in the group. During severe outbreaks, it has destroyed millions of board feet. Loblolly and shortleaf pine are preferred hosts, but it will attack any southern pine species.

The black and red turpentine beetles prefer trees of reduced vigor, but are capable of attacking apparently healthy trees as well. The most destructive populations usually develop in stands disturbed by logging, lightning, or fire. The black turpentine beetle attacks all southern pine species, although it affects loblolly and slash the most severely. The red turpentine beetle attacks all pine species within its range, and occasionally attacks spruce, true firs, Douglas-fir, and larch.

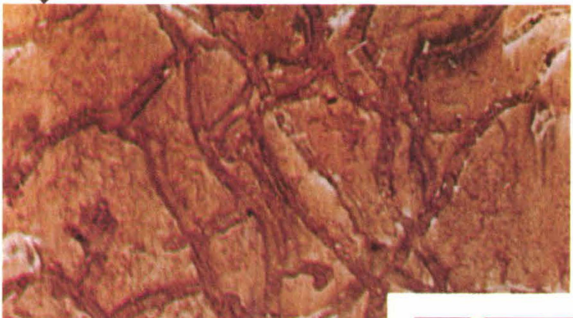
Engraver beetles are second only to the southern pine beetle in the mortality they cause. They usually prefer trees that have been weakened by lightning or other damage, or infest fresh slash remaining after logging operations. *Ips calligraphus, Ips grandicollis,* and *Ips avulsus* attack all southern pine species in their ranges. *Ips pini* attacks all pines in its range and several spruce species, as well.

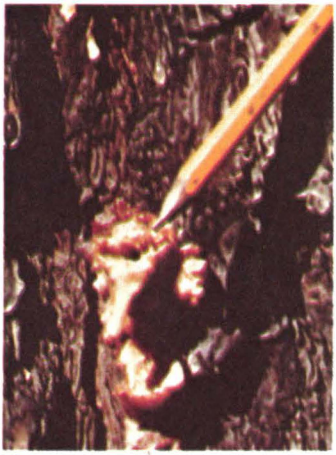
The number of generations per year depends on the location and species of bark beetle.

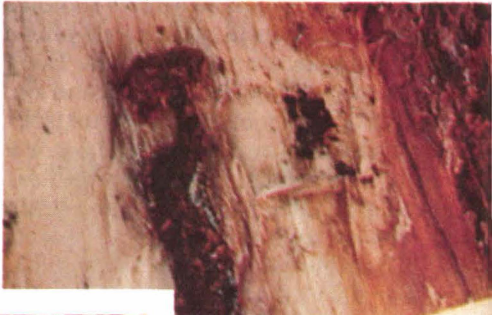
Insect	Description	Mode of Attack	Sign of Attack
Southern pine beetle	Brown-black beetle ⅛ inch long, rounded posterior, with minute notch in front of head when viewed from above.	Bores under bark and girdles southern pines. Attacks middle and upper stem in fall and winter, and lower stem in spring and summer.	Small white pitch tubes on bark or just boring dust. S-shaped and criss-crossed tunnels under bark.
Turpentine beetles	Light reddish brown or black beetles from ¼ to ⅓ inch long with rounded posterior.	Girdles inner bark of stumps and butts of larger pines. Larvae feed in groups. Usually found after fires, logging, or other disturbance.	Large pitch tubes on bark surface at tree base. Tunnels in inner bark are rather shapeless cavities.

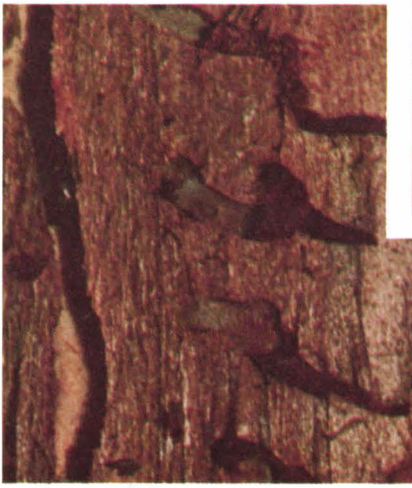
(cont.)

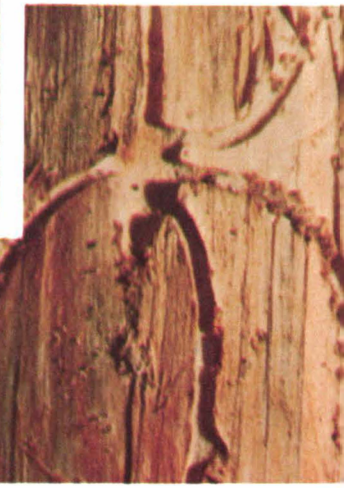
Insect	Description	Mode of Attack	Sign of Attack
Engraver beetles	Reddish dark-brown or black beetles less than ¼ inch long with a posterior that looks cut off and scoop-shaped.	Bores under the bark and girdles small commercial trees.	Small reddish pitch tubes on bark surface or just boring dust in cracks of bark or on ground. Y- or H-shaped tunnels parallel with wood grain on inside bark.


Southern pine beetle adult tunnels


Black turpentine beetle — pitch tubes


Black turpentine beetle adult tunnels


Larval feeding galleries — *Ips pini*

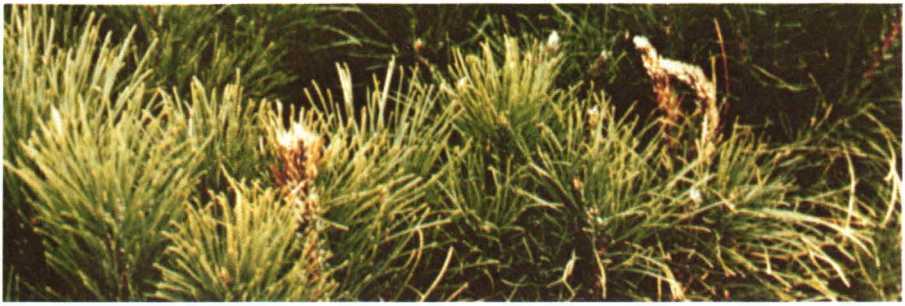

Pine engraver beetle adult tunnels

ADANA TIP MOTH *Rhyacionia adana*

This tip moth mines the current year's shoots of red, jack and Scots pine seedlings and saplings (it attacks the lower halves of trees up to 25 feet tall). Serious damage has been recorded in red and Scots pine plantations in Massachusetts, Pennsylvania, Virginia, Michigan, Wisconsin, and Ontario.

The female lays her eggs between needles just above the sheath of the needle fascicle. Newly hatched larvae spin silken cases between two old needles just above the needle sheath; they then enter the needles and mine toward the tip. After new needle growth has started, larvae enter and mine developing shoots. Several larvae may inhabit a single shoot, moving toward the buds and causing shoot death. In mid-June to late July, mature larvae move down the main stem of the tree and pupate in cocoons cemented to the stem 1 inch below the soil surface. Shoot death becomes apparent after the insect has pupated. A single generation occurs each year.

▼ **Damage**

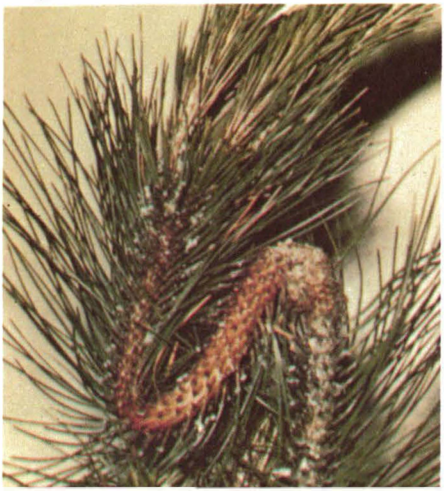


EUROPEAN PINE SHOOT MOTH *Rhyacionia buoliana*

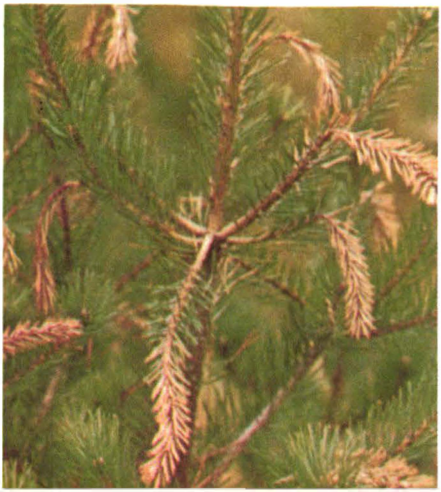
Red, mugho, Scots and Austrian pines are the preferred hosts of this shoot moth, but damage has been recorded on Japanese red, Japanese black, ponderosa, eastern white, jack, pitch, longleaf, and Virginia pines. Young, open-grown pines less than 25 feet tall are most susceptible to attack and damage. Crown closure controls infestations.

The most significant damage occurs in the spring, when larvae tunnel the shoots. Weakened shoots sometimes bend but continue growing, re-

▼ **Post horn injury**



▼ **Shoot injury**



sulting in crooked stems and branches called "post horns." When buds are destroyed, dead or spike tops are produced. Adventitious buds often form below the dead portion, and dense, bushy top growth results the following season.

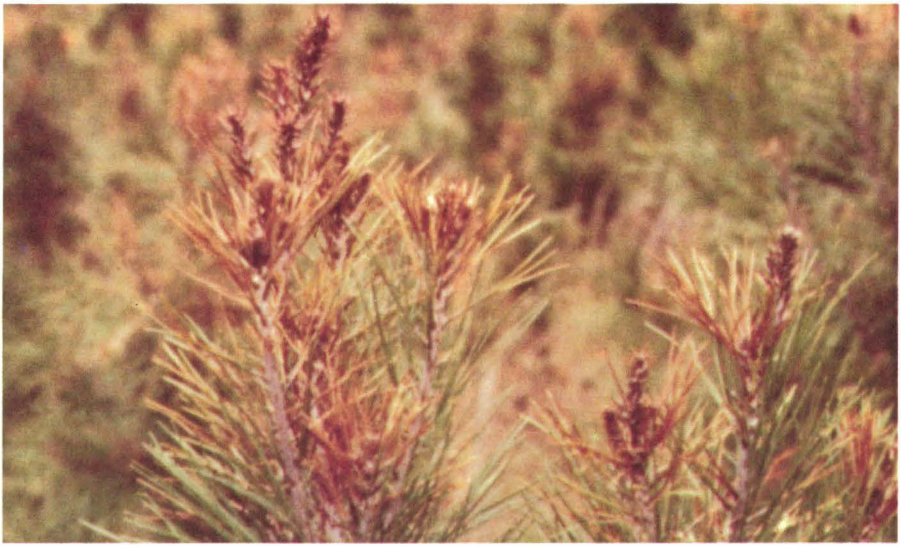
Moths emerge in June and July and lay eggs on new needles. Young larvae spin resin-coated webs between the needle sheaths and stems of the current year's growth. Early feeding occurs within the sheath at the base of the needles. In midsummer, the larvae move to the buds; feeding ceases in August, and the larvae overwinter in resin-coated webs at the bases of buds. In spring, larvae move to undamaged buds or new shoots, where they complete their feeding. The mature larvae are light brown with no distinct lines or other markings. The head, prothoracic shield, and anal plate are black. Pupation takes place during summer in the dead buds and shoots. Adults emerge in about 14 days, leaving the empty pupal cases extending from pupal chambers in the hollowed-out buds. One generation occcurs each year.

NANTUCKET PINE TIP MOTH *Rhyacionia frustrana*

Although this tip moth attacks nearly all species of pine in the Northeast (except white pine), it prefers Scots and shortleaf pines. Young stands are the most vulnerable, with attacks resulting in height growth reduction, stem deformities, poor cone crops, and occasional mortality.

Tip moths overwinter as pupae in the infested trees. Adult moths emerge in early spring, and females deposit yellowish eggs on the needles, axils of needles and stems, or on the buds. Young larvae feed on needles, usually causing the browning of several needles near the terminal bud. Later the larvae consume the buds and bore into the terminal shoots and twigs themselves. The larva is yellowish to pale brown, with the head and thoracic shield dark brown. Mature larvae are about ⅝ inch in length. Low winter temperatures limit the Nantucket pine tip moth in the northern portion of its range. There may be two to three generations per year in the Northeast.

▼ **Damage**

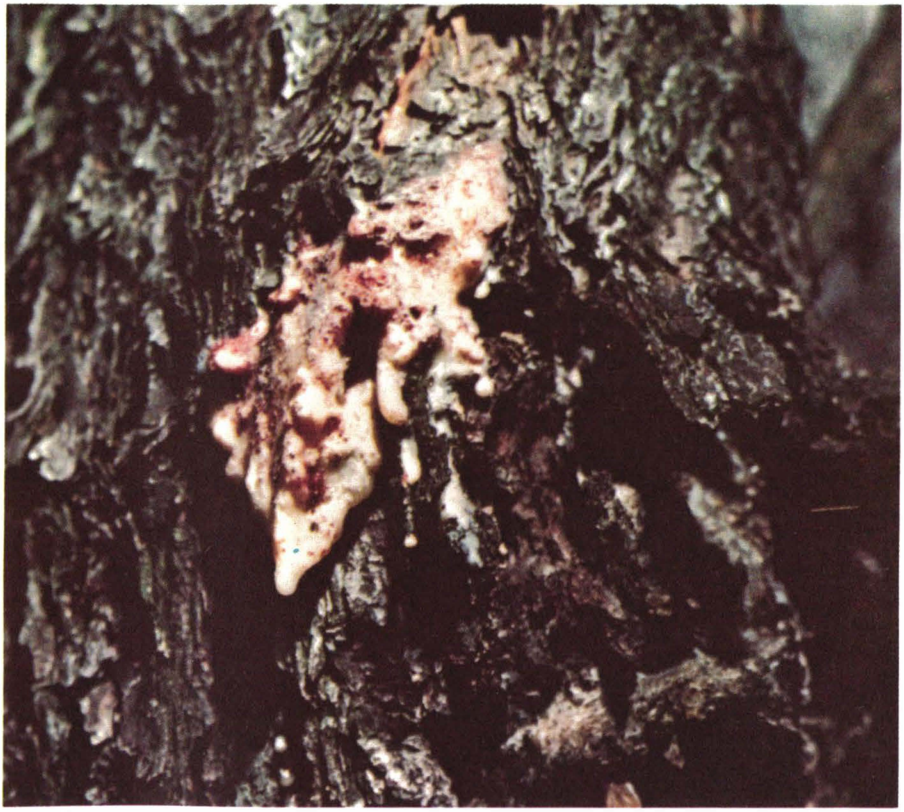


ZIMMERMAN PINE MOTH *Dioryctria zimmermani*

The Zimmerman pine moth prefers the shoots and branches of Scots and Japanese red pines, but also attacks red, jack, white, Austrian, and mugho pines. Trees of all sizes are subject to attack. The damage caused by this insect results in broken, dead tops and branches and burl-like growths on the trunk above the girdled area. The damage often resembles breakage caused by heavy snow, but pitch masses, coarse sawdust, and loose silken webs distinguish damage by this insect.

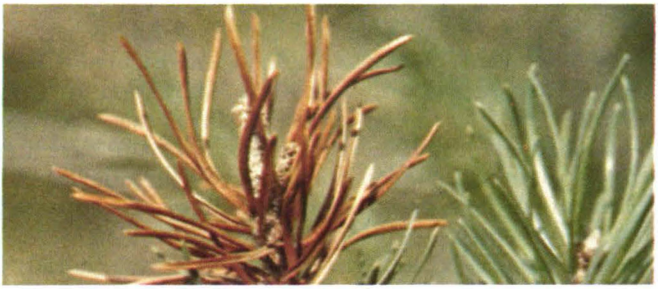
Adults emerge between the end of June and mid-September. They hide during the day and become active at night. The female deposits eggs near edges of wounds, in bark crevices, or on terminal buds. Eggs hatch in 8 to 10 days and young larvae enter bark recesses to spin silken hibernaculae for overwintering. Larvae emerge from May to June; they feed on the bark at first, then mine the new terminal or lateral branches. Larvae leave the new growth sometime in July and tunnel beneath the bark in the whorl area, causing girdled branches and leaders. Mature larvae in the northern part of the range have greenish pink bodies covered with small black spots. They are about ¾ inch long. A heavily infested tree may have 20 or more larvae feeding in a single whorl. Pupation occurs in July within the resin masses or tunnels just under the bark. Adults appear 15 to 23 days after pupation. The life cycle generally takes 1 year from the egg to adult stage, but there are overlapping generations, so most stages can be found at any time of year.

▼ Pitch mass



JACK PINE TIP BEETLE *Conophthorus banksianae*

Jack pine is the primary host of this tip beetle, but Scots and red pines may also be attacked when they are associated with jack pine. Elongating shoots of jack pine begin to wilt in June, and by midsummer infested twig tips turn red or brown. Examination shows an entrance hole with a pitch tube from ½ to 1 inch below the terminal bud cluster. The inside of the tip is tunneled out and may contain a white legless grub, pupa, or the adult beetle. The injury results in excessive branching in the upper half of the tree crown. There are two broods per year.



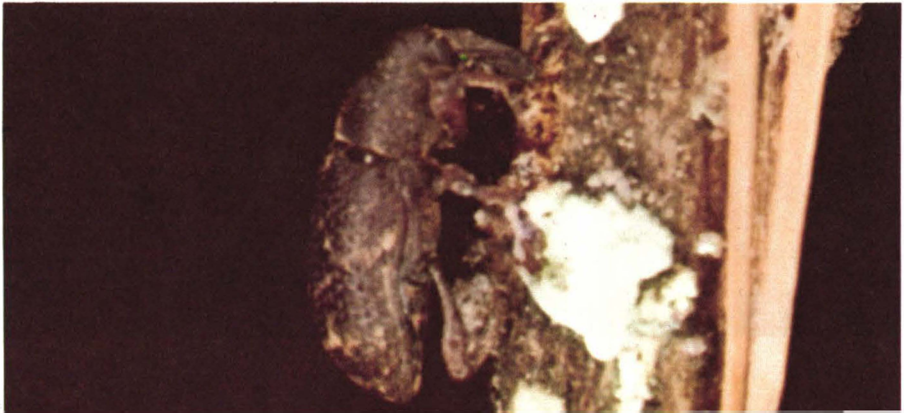
◀ **Injury**

PALES WEEVIL *Hylobius pales*

The pales weevil is a serious pest of young pine, spruce, fir, hemlock, juniper, larch, cedar, and cypress. It girdles and kills seedlings up to ½ inch in diameter and kills the ends of branches on larger trees.

The weevil overwinters either as a white grub in the roots or stump below the ground, or as an adult beneath the litter. In the former case, the larvae pupate in spring to emerge as adults in June or July; in the latter case, adults emerge from May to June. Adult feeding on the tender bark of twigs of larger trees or at the base of seedlings usually occurs after sunset. The daylight hours are spent in hiding. Heavy feeding girdles and kills the seedling, stem, or twig. Adult weevils are attracted to newly logged areas or damaged trees by the odor of fresh pine resin. They feed, mate, and lay their eggs below the root collar of either a fresh pine stump or weakened tree. Grubs begin feeding on the inner bark tissues and continue until early fall. Mature grubs construct a chip cocoon in the wood and pupate. The reddish-brown adults emerge in about 3 weeks, in late September or October. They feed on pine bark, twigs, and needles until they enter the litter to hibernate. The life cycle in the northern United States requires 2 years.

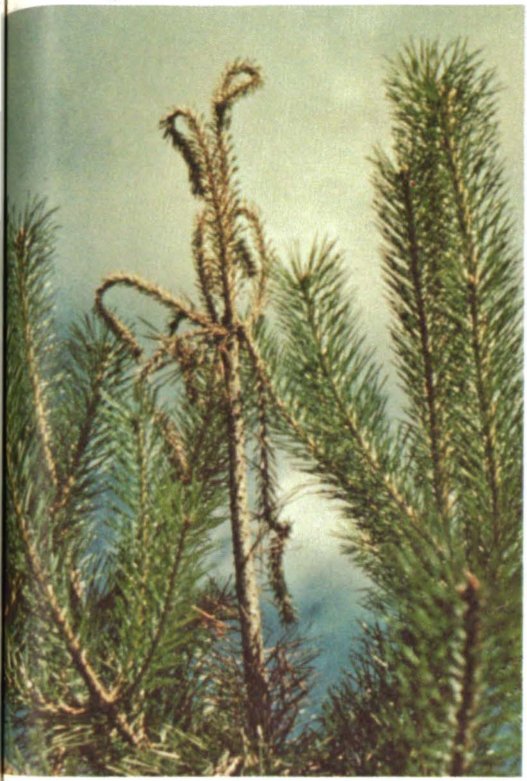
▼ **Feeding adult**



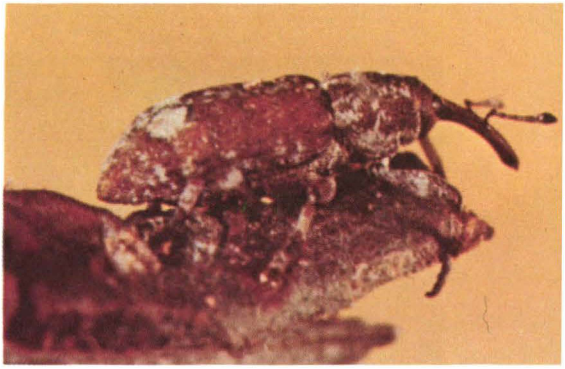
WHITE PINE WEEVIL *Pissodes strobi*

The white pine weevil is a serious pest throughout the range of its preferred host, eastern white pine. Other hosts, in descending order of preference, are Norway spruce, jack pine, Scots pine, pitch pine, and red pine. Open-grown white pines in old-field plantations are highly susceptible to infestation and rapid weevil buildup. Evidence of weevil attack first shows in the spring as pitch flows from feeding punctures on the preceding year's leader. During summer, new growth is stunted; eventually the needles wilt and the bark shrivels, turning a reddish brown. Trees less than 3 feet in height may be killed. The dead leaders are replaced by one or more of the lateral shoots, resulting in a crooked or forked stem. Successive weeviling over a number of years results in multiple-stemmed trees.

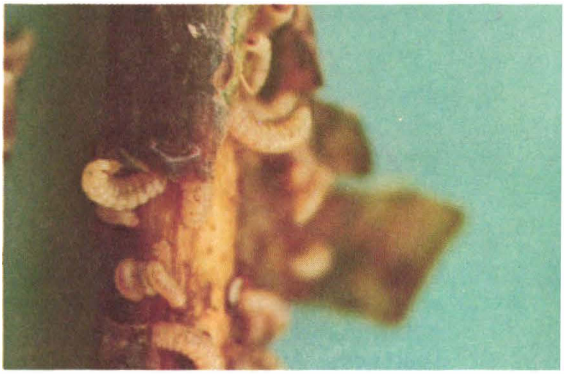
▼ **Injured terminal**



▼ **Adult**



▼ **Larvae feeding**



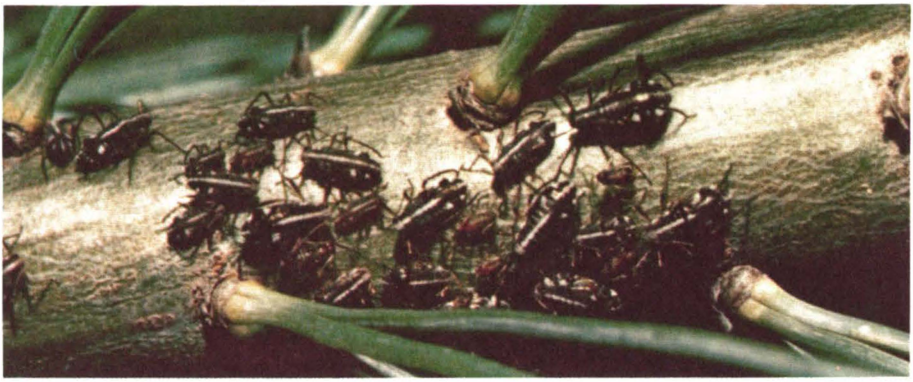
The adult weevils overwinter in the duff. They emerge from March to May and crawl or fly to host trees, where they feed on the previous season's leader and deposit their eggs in small niches under the bark. The eggs hatch in 7 to 10 days, and the legless white grubs position themselves around the shoot and feed as a group on the inner and outer wood, tunneling downward. The portion of the branch above the lowest level of feeding dies by late summer. Mature larvae construct pupal chambers in the pith of the terminal shoot, and young adults emerge in 10 to 15 days. They feed on old and new branches until cold weather forces them to hibernate. There is one generation per year.

WHITE PINE APHID *Cinara strobi*

The white pine aphid feeds only on eastern white pine, damaging twigs and branches of large trees and sometimes killing small trees. Serious damage occurs only in white pine plantations and on shade trees. The first evidence of infestation is usually a blackening of twigs and branches caused by a sooty mold. The mold grows on the large amounts of honeydew produced by the feeding aphids.

The life cycle of this aphid is complicated, and the following description is somewhat simplified. Winged females, which are about ¼ inch long, deposit their five or six yellow eggs in lines on needles in the fall. Shortly after the eggs are laid, they turn jet black. The eggs hatch in May and June, and the young aphids move to the twigs and smaller branches to feed, usually in colonies. Several wingless generations are produced throughout the summer, and winged females are again produced in the fall.

▼ **Wingless adults and nymphs**

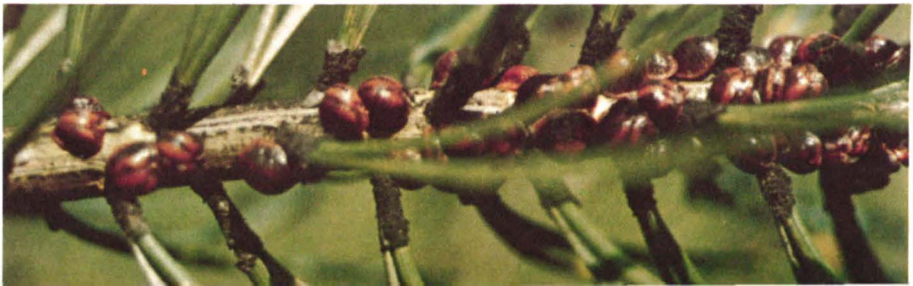


PINE TORTOISE SCALE *Toumeyella parvicornis*

The pine tortoise scale infests Scots, Austrian, and jack pines. Pole-sized stands occasionally are infested severely, but seedlings and young saplings receive the most damage. Heavily infested pines become covered with a black, sooty mold. Needle fall is unusually heavy, and needles are much shorter than normal. Heavy feeding may cause branch mortality or death of the entire tree.

Partly grown females spend their first winter on twigs. When growth is completed the following spring, they lay eggs under themselves. The eggs hatch in June or July, and the young larvae immediately begin feeding on the twigs. Adult males emerge in about 3 weeks and fly off in search of females, which are still immature. A few days after mating, the males die. The females continue to develop slowly until late fall, then they hibernate. There is one generation per year.

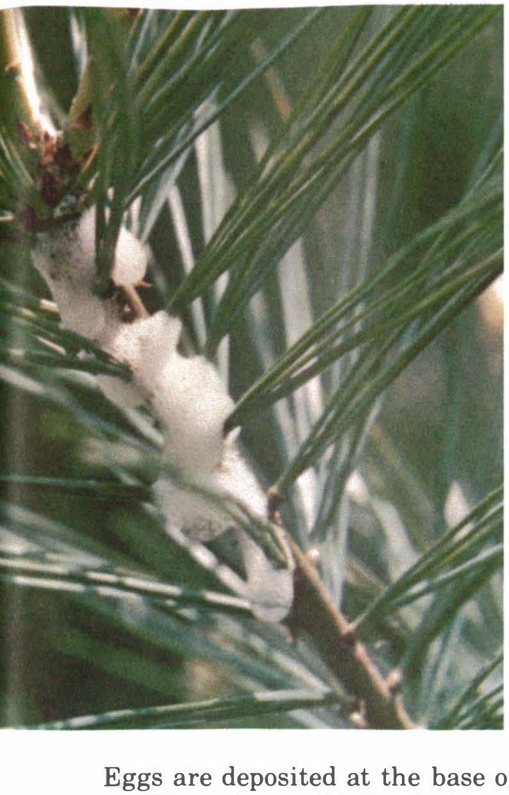
▼ **Female scales**



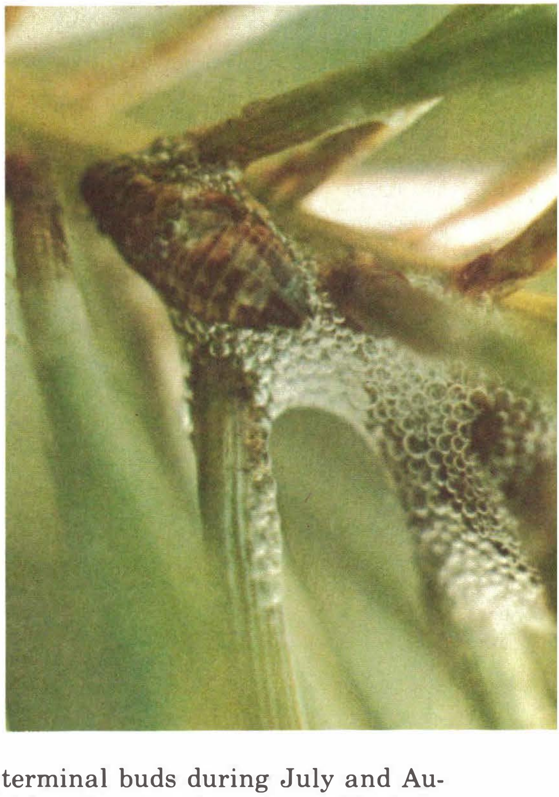
PINE SPITTLEBUG *Aphrophora parallela*

The pine spittlebug is a common sap-sucking pest of many coniferous species. It prefers Scots pine, but also attacks pitch, western white, jack, slash, Virginia, loblolly, and Japanese pines; Norway, white, and red spruce; balsam fir; and eastern hemlock. Damage includes yellowing of foliage, growth loss, twig mortality, and in heavy infestations, tree death. Branch flagging progresses from new to old growth on each branch. Lower branches are the first to show effects of feeding. The overall injury resembles that caused by the Saratoga spittlebug, Scleroderris canker, or drought. Pine spittlebug infestations are identified by the presence of spittle masses. Blackened foliage, caused by growth of sooty mold fungus, may indicate old infestations.

▼ **Spittle mass**



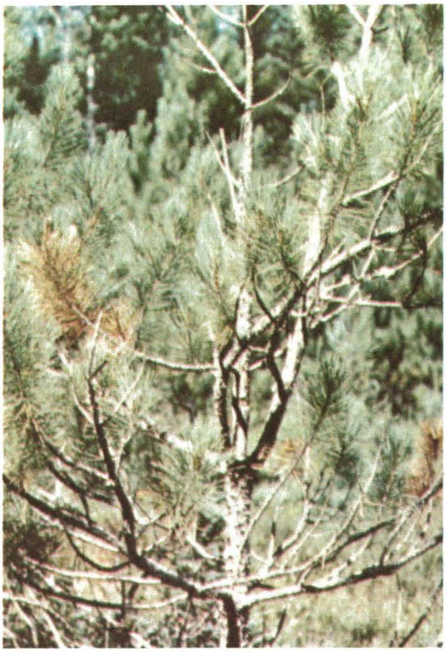
▼ **Nymph**



Eggs are deposited at the base of terminal buds during July and August. When they hatch the following May, the nymphs move to the twig tips and begin feeding. The nymphs keep covered with spittle at each new location as they move toward the main trunk. A single spittle mass may have several nymphs. Young nymphs are orange and black, while full-grown nymphs range from light brown to black. Mature nymphs leave the spittle and migrate to needles, where they transform to winged adults. Adult pine spittlebugs resemble Saratoga spittlebugs in shape and color but do not have the white "arrow" design on the head and thorax. Adults continue feeding through July and August. Mating occurs about 1 week after adult emergence; egg laying continues until the first week in September. There is one generation per year.

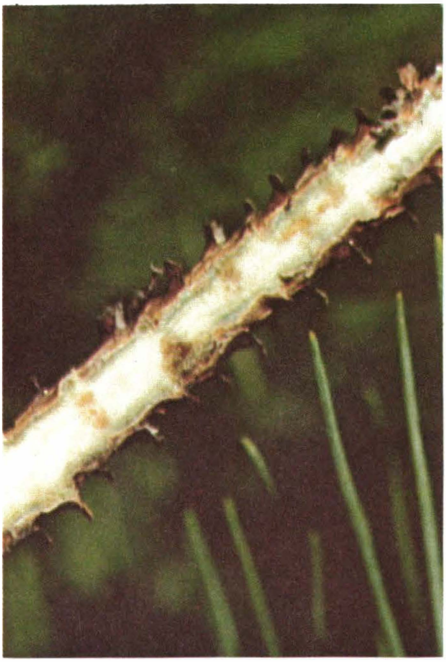
SARATOGA SPITTLEBUG *Aphrophora saratogensis*

The Saratoga spittlebug, a sap-sucking insect, causes growth loss and tree mortality of young red and jack pines 2 to 15 feet in height. Scots pine may also occasionally be attacked. Characteristic symptoms of infestation are reddish-brown "flags" of dead foliage, numerous punctures on the twigs covered with small drops of pitch, and light-tan flecks in the inner bark and wood at the feeding points. Old damage is characterized by shortened stem or branch intervals. The overall injury resembles that from pine spittlebug, Scleroderris canker, and drought.



▲ **Injury**

▼ **Adult feeding punctures**



On red pine, eggs are deposited in the fall under the outer scales of terminal buds on the upper part of the tree. On jack pine, eggs are deposited in needle sheaths of the current year's growth or under bark of dead twigs. After hatching the following spring, young nymphs crawl to the ground and feed at the bases of herbaceous plants. The preferred host is sweet fern, but most ground plants (except grasses, lichens, and sedges) are used. Nymphs feed singly or in groups, forming white spittle masses to protect themselves against desiccation (spittle masses are not formed on host trees). Young nymphs are red and black, turning chestnut brown as they approach adulthood. The nymphal stage lasts 40 to 70 days. Adult spittlebugs feed on host trees from late July to early September. They have a whitish "arrow" design covering the head and thorax. There is one generation per year.

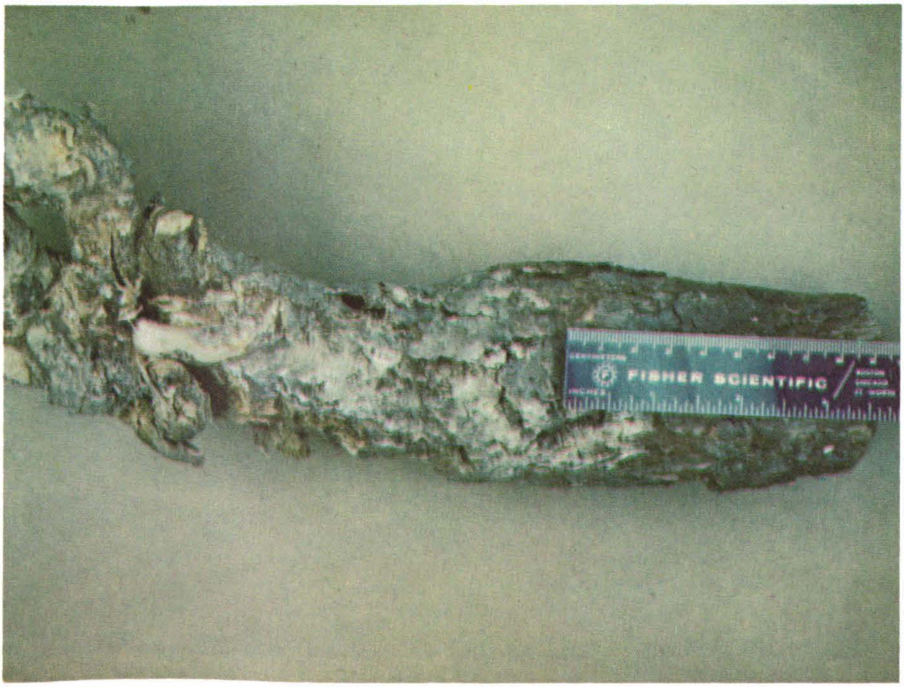
PINE ROOT COLLAR WEEVIL *Hylobius radicis*

All hard pines are attacked heavily by pine root collar weevil, although Scots pine is most noticeably damaged. Eastern white pine is also attacked by adult weevils, but rarely by larvae. In plantations, weevil populations are favored by wide tree spacing, especially between the fifth and tenth year of growth. In forest environments, jack and red pines rarely are damaged because of denser stocking.

Repeated injury to hard pines results in girdling and death of small trees (2 to 20 feet tall) and stunting and breakage of larger ones, especially those growing in windrows or open, park-like stands. The larvae injure the bark and cambium of the host at the base near the root crown. Adults feed on the bark of twigs, causing flagging of branches. The root collar of an attacked tree often is constricted, and the soil around it pitch-soaked and blackened.

Eggs are laid from early May to late September in the bark at the base of the tree or in the soil nearby. They hatch in about 2 weeks, and the grubs feed and tunnel under the bark of primary roots and at the root collar. Galleries are irregular, with occasional mined-out areas the size of half dollars. Sometimes grubs tunnel into the soil. The larvae overwinter in the galleries and resume feeding in the spring. Pupation occurs from early June through September. Young adults feed on the branches, overwinter under the tree in the duff, and resume activity in the spring. This insect usually has one generation per year but the life stages overlap, and all of them may be found during the summer. The adults may overwinter a second time and continue to lay eggs the second summer.

▼ **Damage**



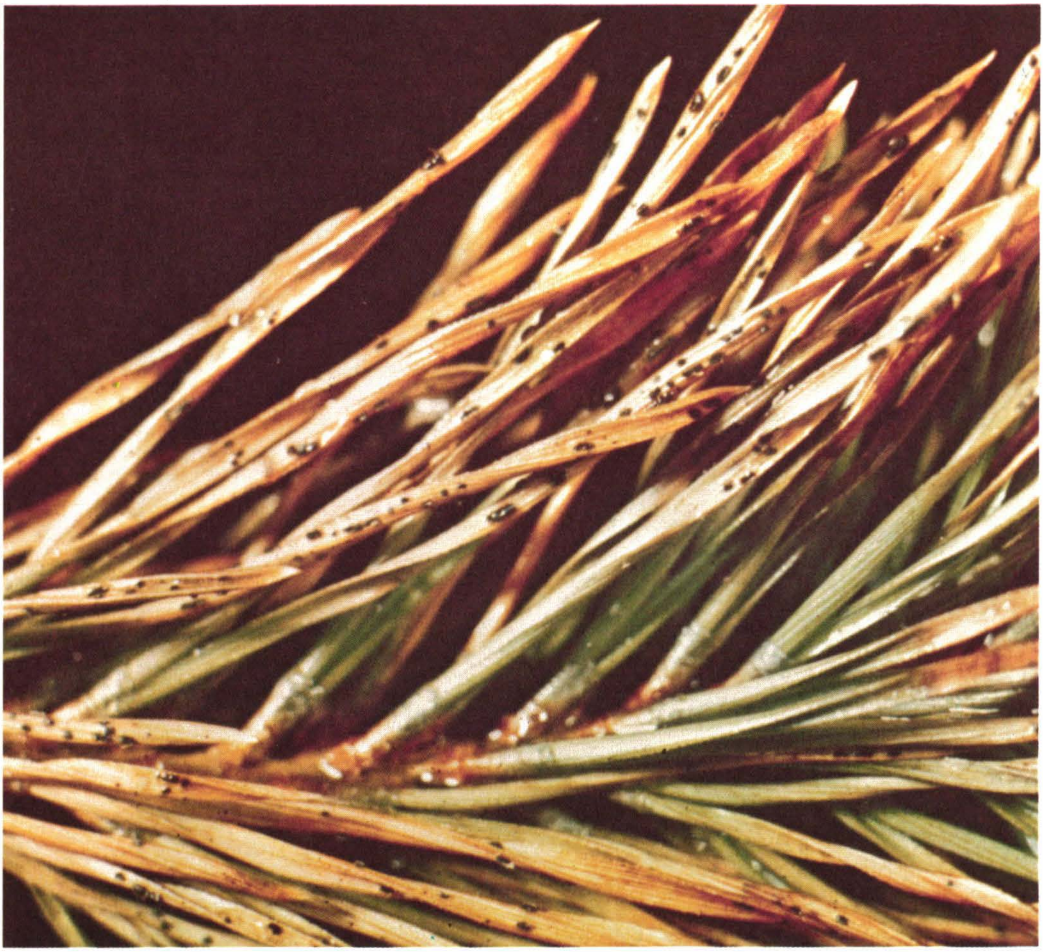
BROWNSPOT NEEDLE CAST

Brownspot needle cast, caused by the fungus *Scirrhia acicola,* spoils the appearance of Scots pine grown for Christmas trees. The disease has been reported in Minnesota, Wisconsin, Iowa and Missouri. Short-needled pine varieties are less resistant to the fungus than long-needled varieties.

Yellow spots with brown centers develop in the infected needles in late August. Needles of all ages are susceptible. The infected needles are usually found on the lower half of the tree, especially on the north side. Needles die from the tips back until the entire needle becomes brown and falls off during September, October, or November. Whole branches and parts of the crown become bare, and the trees become useless for Christmas trees. The buds normally remain alive and produce new needles the next spring.

The fungal spores appear on the needles from June to September. The spores are spread by splashing rain or by Christmas tree shearing tools.

▼ **Fruiting bodies on needles**

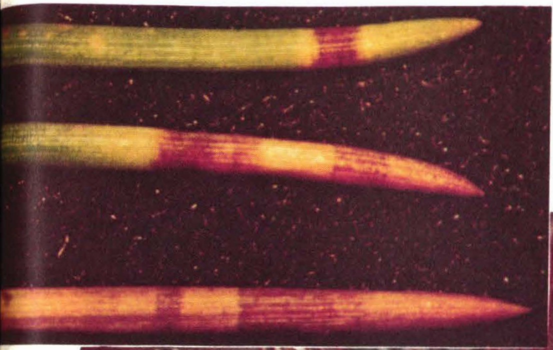


DOTHISTROMA NEEDLE CAST

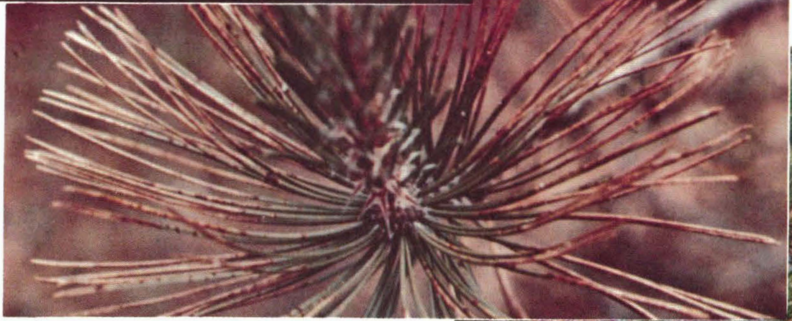
The Dothistroma needle cast disease, caused by *Dothistroma pini,* affects several western pine species (Monterey, ponderosa, lodgepole), but the species most seriously affected in the northeastern United States is Austrian pine.

Infection first appears as yellow and tan spots in bands extending around the needles. The bands often turn red, and the disease is sometimes called the red band disease or red-banded needle blight. Both old and new needles may be infected, but the infection periods differ. Old needles infected from mid-May to mid-June will turn brown by late fall. New needles infected in mid-July will turn brown in late summer of the following year. Thus, banding may appear on old or new needles, but browning is confined to the old needles. The lower portion of the tree is affected first, and then the disease progresses upward.

The fungus has a sexual stage, but it has been found only in the West. Asexual fruiting bodies form beneath the surface of infected needles and spores burst out. Sometimes a split in the needle surface will appear in the fall after infection, but spores usually are not produced until spring. The spores, released whenever it rains between May and October, are spread by splashing rain.



◀ **Red bands on needles**



▲ **Infected needles**

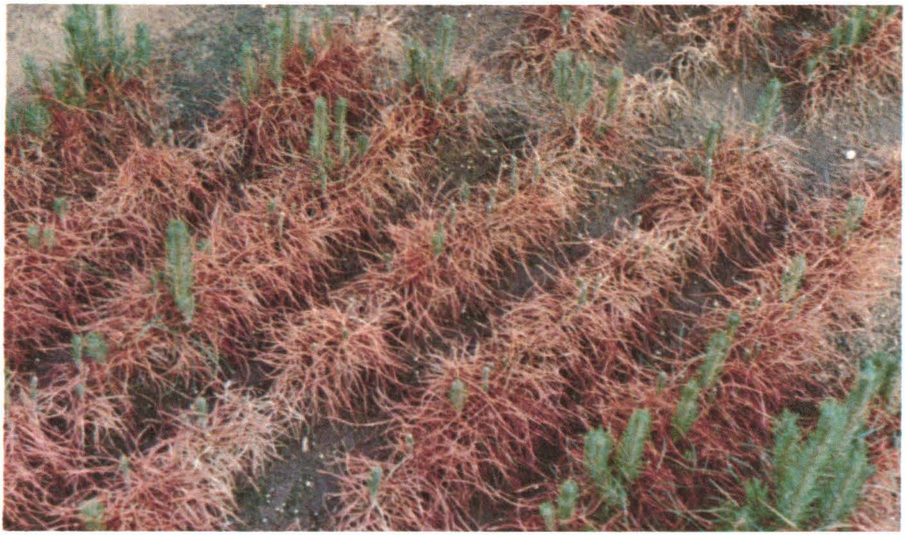
Damage ▶

LOPHODERMIUM NEEDLE CAST

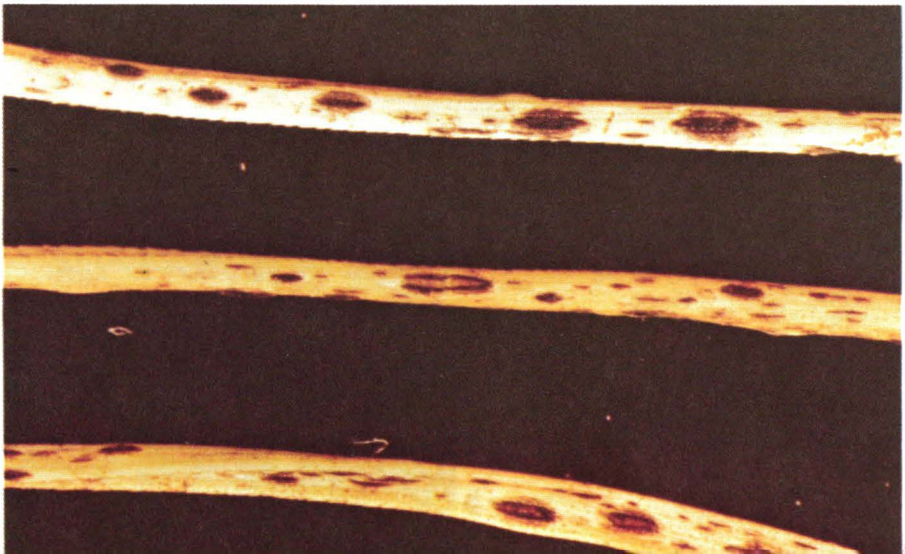
Lophodermium needle cast, caused by the fungus *Lophodermium pinastri,* kills or damages red pine seedlings and Scots pines of all ages. The disease is found throughout most of the Northeast. The damage usually is more severe on the lower part of the tree, but the whole tree may become infected. Generally, Christmas trees survive but are unmarketable. Nursery seedlings may be killed, and entire beds often turn brown. Some Scots pine varieties are resistant to the disease.

Small gray-black spots form on the needles in the spring. The spots later turn brown with yellow margins. The entire needle eventually turns yellow and then brown. Trees with green foliage on tips of branches, but dead or missing 2- and 3-year-old needles, may have had Lophodermium needle cast. Small, black fruiting bodies form on dead needles, and during moist periods in the fall, wind spreads the spores to healthy needles.

▼ **Infected seedlings**



▼ **Fruiting structures**



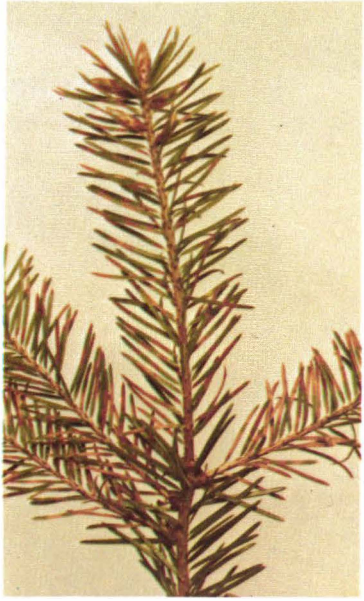
RHABDOCLINE NEEDLE CAST

Rhabdocline needle cast, caused by *Rhabdocline pseudotsugae,* is a foliage disease of Douglas-fir. The disease may be found wherever Douglas-fir is native or has been introduced. In the northeastern United States, this needle cast has been a problem on shade trees and in Christmas tree plantations. Individual trees may be resistant.

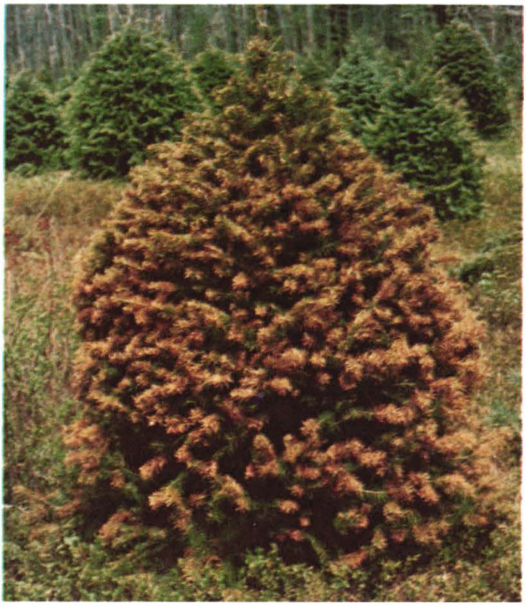
The first signs of the disease are pale yellow lesions on needles in the fall. These spots turn reddish brown in late fall or winter. The reddish brown spotted needles, or scorched-brown needles in severe cases, remain until the spores are released the next spring. Severe infestations completely remove the older needles, leaving only the current year's needles on the tree.

The fruiting bodies develop on either surface of the needle. At first, elongated swellings appear along the midrib. The swellings split at maturity and release spores which are transported by wind to new shoots in the spring.

▼ **Needle spots**



▼ **Infected tree**



▼ **Elongated swellings on needles**

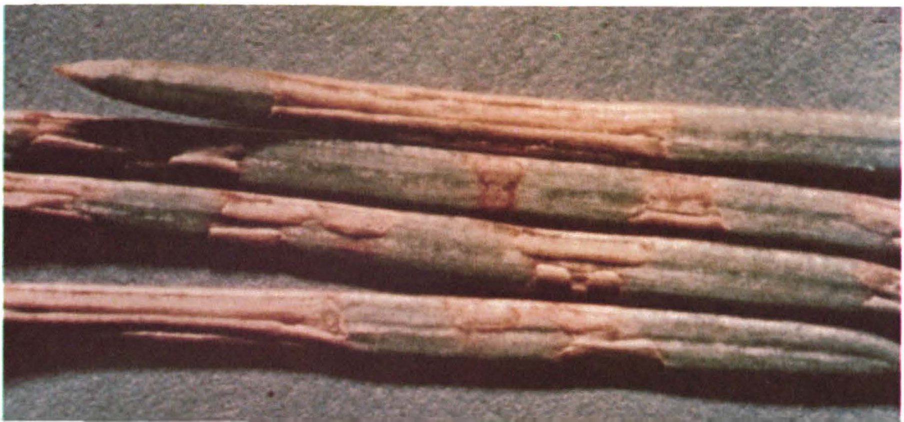


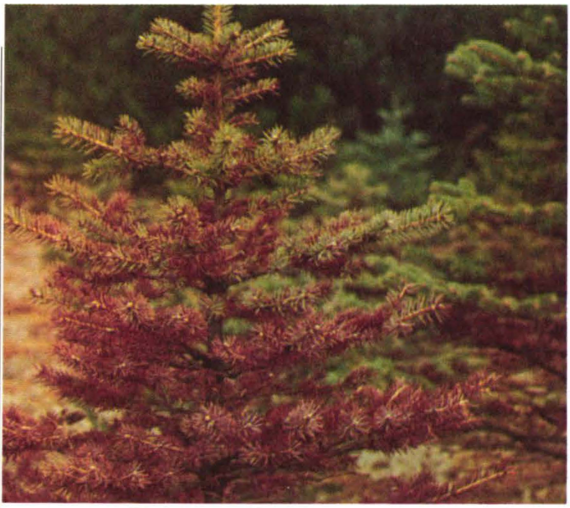
Photo credit: Harrison Morton, Univ. of Michigan

RHIZOSPHAERA NEEDLE CAST

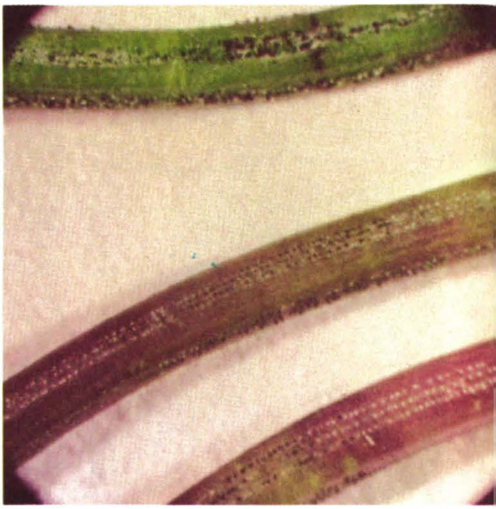
Rhizosphaera needle cast, caused by *Rhizosphaera kalkhoffii,* is a foliage disease of blue and white spruce. Shade trees, ornamentals, Christmas trees, and seedlings in nurseries are affected. Some blue spruce trees appear resistant to the fungus, and plantations have individual trees that are not affected. Damage in forest stands is rarely significant.

The fungus attacks needles on the lower tree branches first, then moves upward. The 1-year-old needles become infected in May and June and drop prematurely in late fall or the following spring. The infected needles turn yellow and then purplish brown before they drop. Small fruiting bodies develop in the stomatal openings of the needles in late fall or early spring. The fruiting bodies appear as tiny black dots in rows along the needle surface. The disease is spread to nearby healthy trees by wind-borne spores; it has been spread long distances through transportation and planting of infected nursery stock.

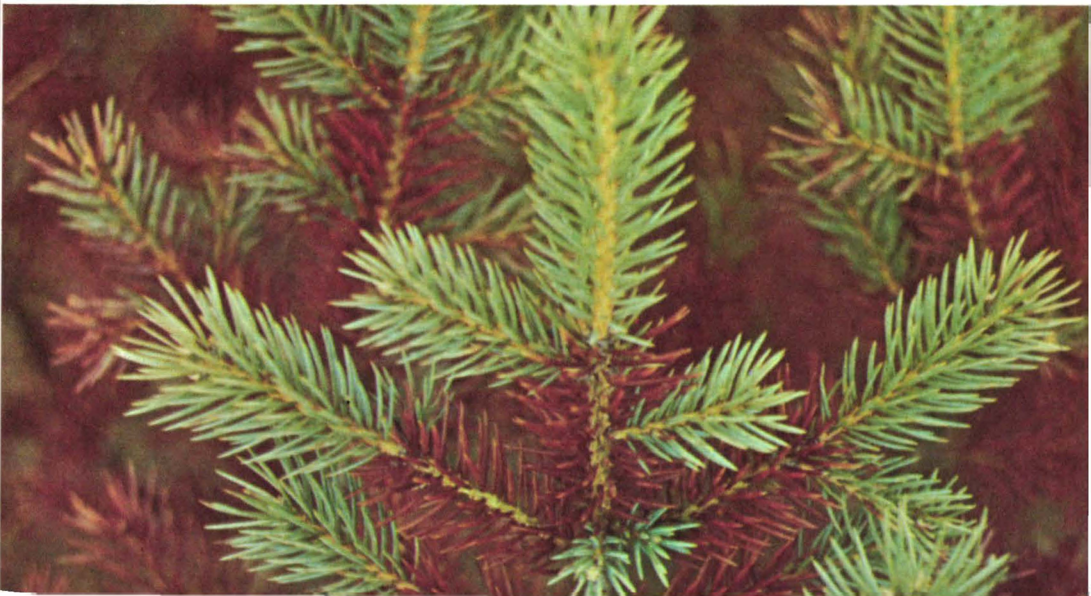
▼ **Purple color of infected tree**



▼ **Fruiting bodies on needles**



▼ **Infected branches**



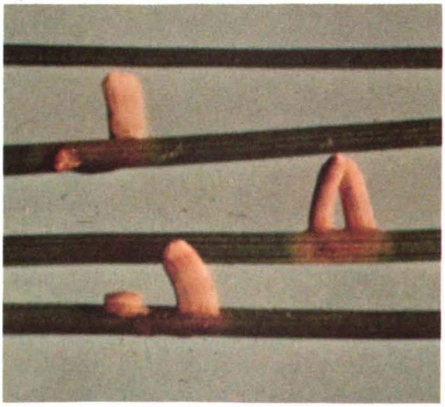
RUSTS

The life cycles of rust fungi are complex. Most rusts have five reproductive stages; typically, three stages are found on one host species, the other two on the alternate host species. The term "rust" comes from the rusty appearance the fungus gives to cereal grains during the uredial stage. Uredia are fruiting bodies that produce wind-borne urediospores. Urediospores reinfect the same plant or infect other host plants of the same species, causing infection to escalate. Urediospores are hardy and can be dispersed over long distances. In late summer telia form in the uredia, and the fungi often overwinter in the teliospore stage. The teliospores germinate to form basidia (fruiting bodies). Under the proper conditions of temperature and moisture, basidiospores are produced and carried by the wind short distances to the alternate host. The basidiospores germinate on the alternate host and usually enter through the openings (stomata) in leaves or needles. Eventually pycnia form, which produce pycniospores. Two pycniospores combine and germinate to form aecia, which produce aeciospores. The aeciospores will not infect the alternate host; they must infect the first host species. Uredia then form on the first host species, completing the life cycle.

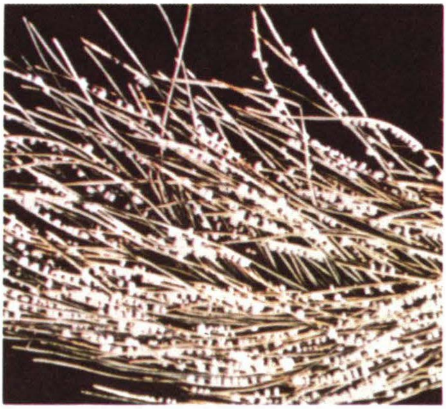
PINE NEEDLE RUST

Pine needle rusts are caused by fungi of the genus *Coleosporium*. These fungi attack the needles of two- and three-needled pines throughout the northern United States. Needle rusts may cause defoliation and stunt young pines, but they seldom injure older trees. The alternate hosts are herbaceous plants from several families, including Compositae, Convolvulaceae, and Campanulaceae. Asters and goldenrods (Compositae) are common hosts.

▼ **Aecia on needles**



▼ **Aecia on needles**



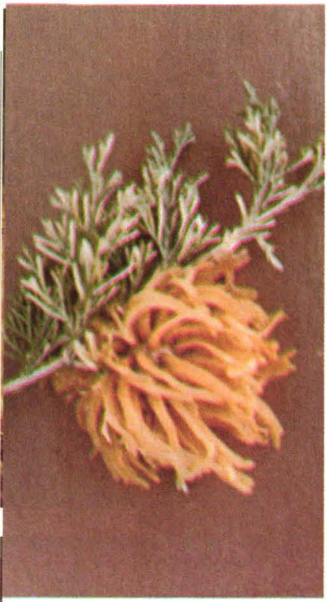
The fungus appears in the spring or summer as small cream-colored pustules (aecia) on infected needles. The spores produced in these fruiting structures are blown to the alternate host. Fruiting structures are then formed on the leaves of the alternate host. The rust fungus may overwinter in the uredial stage and can live indefinitely on the alternate hosts. The spores produced in the uredia infect the same or other alternate hosts. Later in the summer and fall, telia are formed. Basidiospores produced on the telia are blown to and infect pine needles, thus completing the life cycle.

CEDAR APPLE RUST

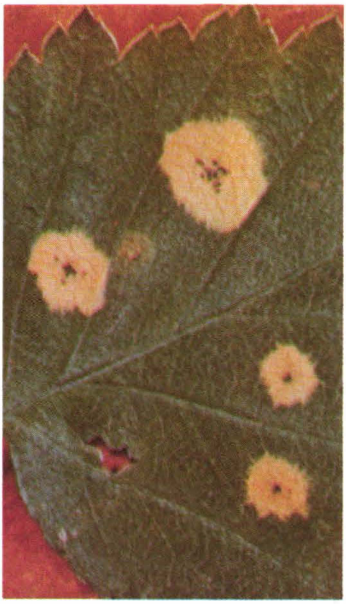
Cedar apple rust is caused by the fungus *Gymnosporangium juniperi-virginianae*. The fungus is common on eastern red-cedar and several other juniper species. The alternate host, which receives the major injury, is apple or crabapple. The rust affects leaves, twigs, and fruit, causing premature defoliation, dwarfing, and poor-quality fruit. Very susceptible crabapple trees may be killed.

Most junipers are relatively resistant to the rust, which infects twigs and leaves. The infected tissues form galls, which enlarge until the second spring after infection. Mature stem galls are up to 2 inches in diameter. During spring rains, many gelatinous, orange spore-horns (telia) protrude from pits on the surface of the cedar galls. Spores from these horns are carried by wind and insects to leaves or fruit of nearby apple or crabapple trees.

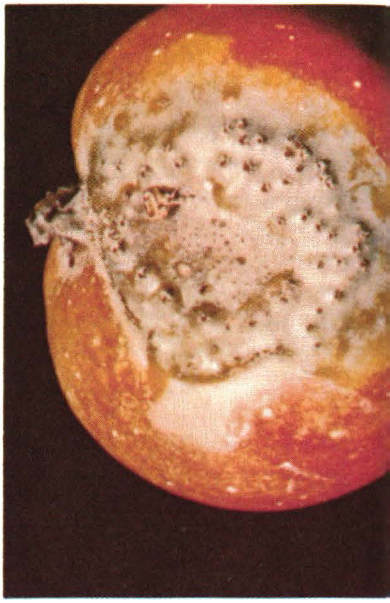
▼ **Telia on cedar**



▼ **Aecia on crabapple leaf**



▼ **Aecia on apple**



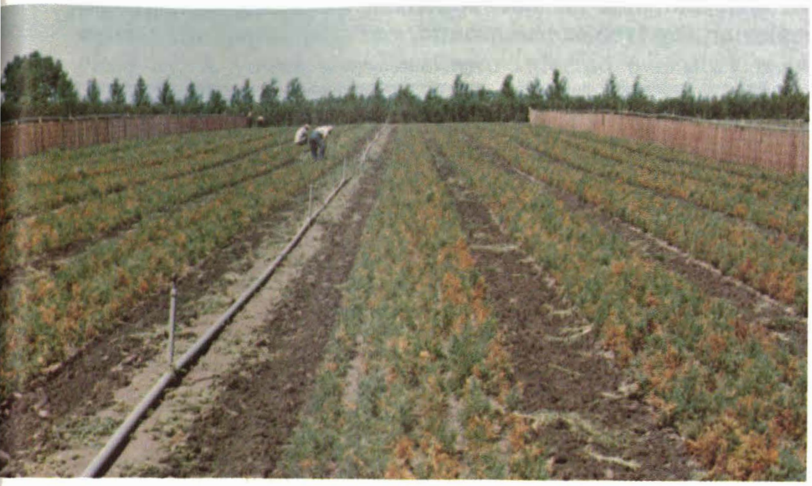
Swollen lesions about 1 inch long form on current-year twigs of apple and crabapple, and fruiting bodies of the fungus develop in these lesions. In May, very small, pale-yellow spots appear on apple leaves. They enlarge to about ⅜ inch in diameter, becoming yellowish orange and frequently bordered by a red band. Fruiting bodies may also appear near the stem end of apples. Aeciospores are produced in late summer and are carried by the wind to junipers, which are infected through the leaves or young stems. The fungus overwinters in the coniferous host. Galls form the first year, but telia are not produced until the second year. Uredia are not formed.

The entire life cycle takes 2 years — 18 to 20 months on the juniper and 4 to 6 months on the apple. Junipers planted within a mile of apple or crabapple trees should be rust-resistant species or varieties.

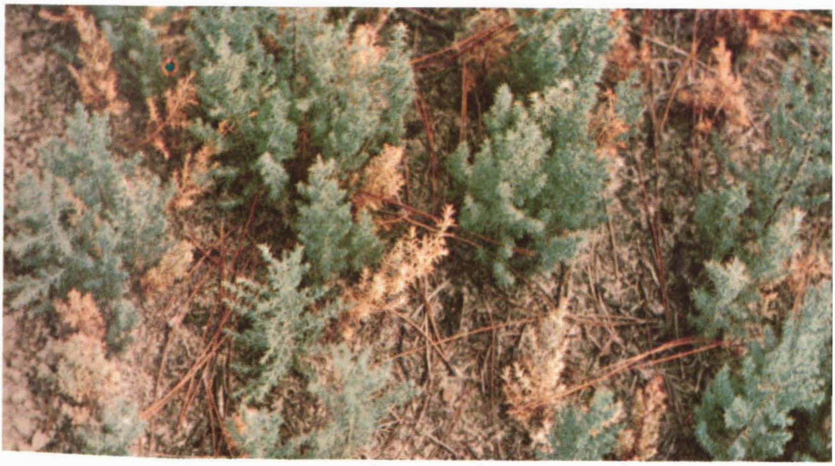
PHOMOPSIS BLIGHT OF CEDAR

Phomopsis blight is caused by the fungus *Phomopsis juniperovora*. It infects junipers, cypress, and northern white cedar. During wet weather, the fungus can cause extensive tip blight and stem dieback, and may kill susceptible nursery plants. Infected junipers in landscape plantings may have numerous dead branch tips, but are seldom killed because only small-diameter stems are girdled.

First symptoms of the disease are small yellow spots on current-season needles. Tips eventually become yellowish, then reddish brown, and finally ash-gray. Phomopsis blight should not be confused with Cercospora blight, caused by *Cercospora sequoiae*. Cercospora blight affects only the needles — it starts with the oldest needles of lower branches, then spreads upward and outward. *Phomopsis* infection, however, starts in newly developed needles and spreads to stems. Minute black fruiting bodies of *P. juniperovora* may be found on diseased trees. During wet weather, spores ooze out of these fruiting bodies in long threads and are spread chiefly by rain and overhead irrigation. The fungus can live in dead portions of the trees and produce spores for up to 2 years.



Infected nursery beds



Infected trees

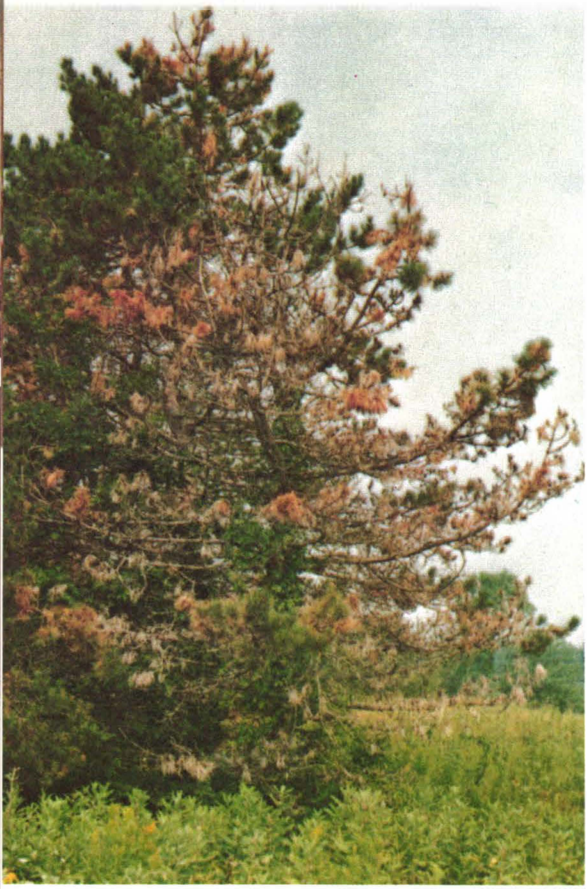
PINE TIP BLIGHT

Pine tip blight, caused by the fungus *Diplodia pinea*, attacks all pine species. Austrian pine is particularly susceptible. This fungus, which usually infects the current year's growth, readily kills seedlings; large trees can be killed by repeated attacks. Large trees also can be killed or deformed when the fungus causes stem cankers.

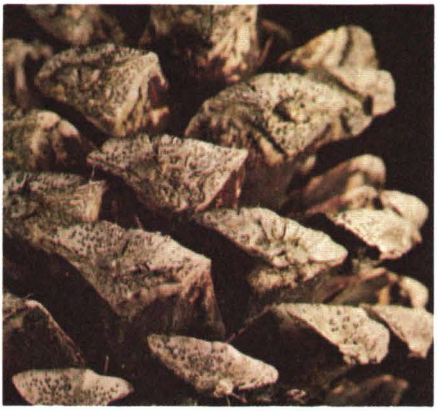
Infection usually begins in the lower branches and over a period of years progresses upward. Spores carry the fungus from branch to branch or tree to tree. The spores infect needles, branches, and cones. Large stem cankers may form when the fungus enters the base of branches, apparently through wounds. Such wounds may be created by the bending of branches under the weight of snow.

Browning of the needles at their bases is an early sign of shoot infection. Infected shoots produce resin, which holds the dead needles onto the twig. Tiny, black fruiting bodies form under the needle sheaths and later over the entire needle. Fruiting bodies also may form just under the surface of shoot stems or on cones. Spores ooze out of the fruiting bodies during wet weather and are carried to new infection sites by rain. *D. pinea* survives for some time on dead material, including seeds, cones, bark, and needles on the tree or the ground.

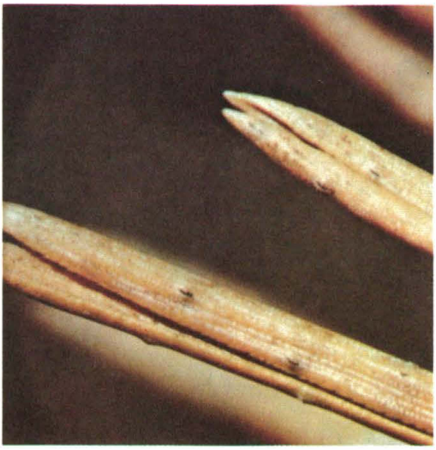
▼ **Infected tree**



▼ **Infected cone**



▼ **Fruiting bodies on needles**

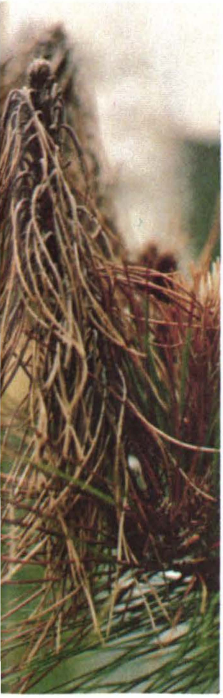


SIROCOCCUS SHOOT BLIGHT OF RED PINE

Sirococcus strobilinus, formerly called *Ascochyta piniperda*, attacks several conifers in the northeastern United States, but causes the most serious damage to red pine. The fungus attacks only the new shoots or buds, killing them 4 to 6 weeks after infection. Often the needles collapse at their bases, giving the shoot a drooped appearance. The dead needles do not drop for 2 years or more. After repeated attacks, the tree may die.

The spring after the shoots die, fruiting bodies form on the needles (often only beneath the needle sheaths), and sometimes on the shoot stems. The fruiting bodies are first brown, then black, barely visible to the unaided eye, and irregular in size and shape. During wet weather, especially in May and June, spores ooze from the fruiting bodies and are carried to healthy shoots in rain or dew. Ordinarily, the disease spreads only short distances in a single year. Natural long-distance spread occurs occasionally, but the mechanism is unknown.

On large trees the infection may remain in the lower crown, with the symptoms mistaken for normal shading. Sometimes, though, spores are borne upward as branches move about in the wind; the infection can advance upward from branch to branch until the tree is killed. Rain carries the spores from large trees to smaller trees that may be beneath or close by. A young stand with an infected overstory may be damaged severely.



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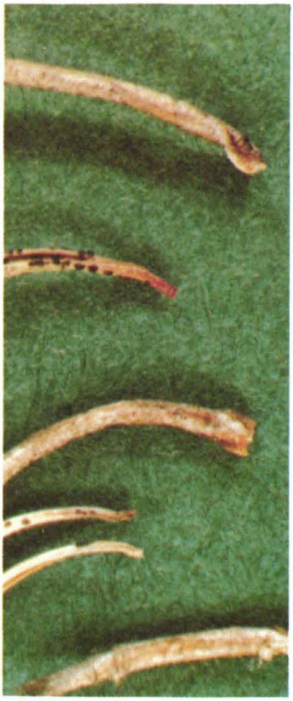
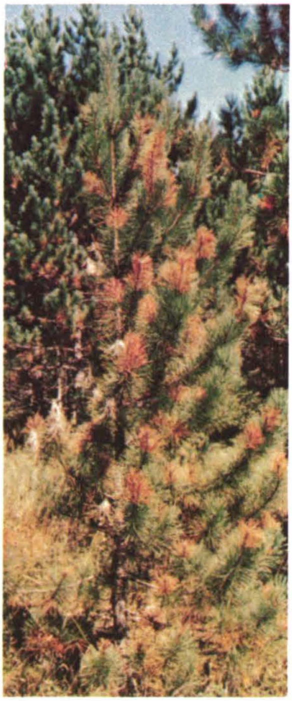
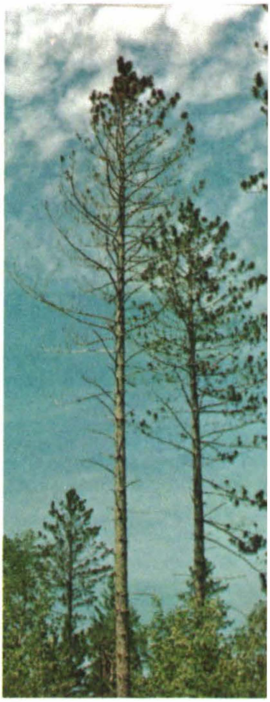


Fruiting
bodies on
needles



Infected
sapling



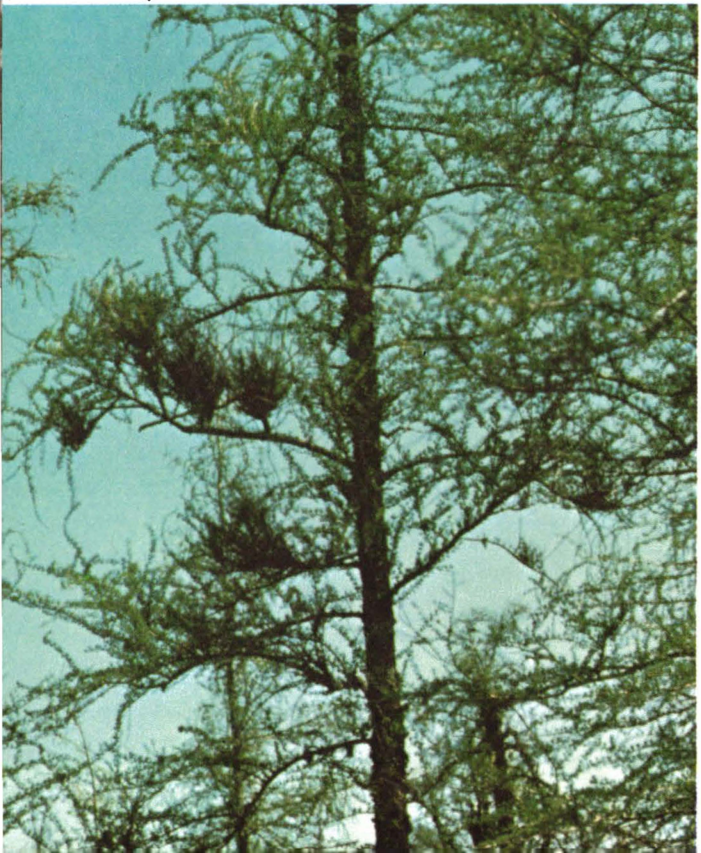
Infected
large
tree

DWARF MISTLETOE

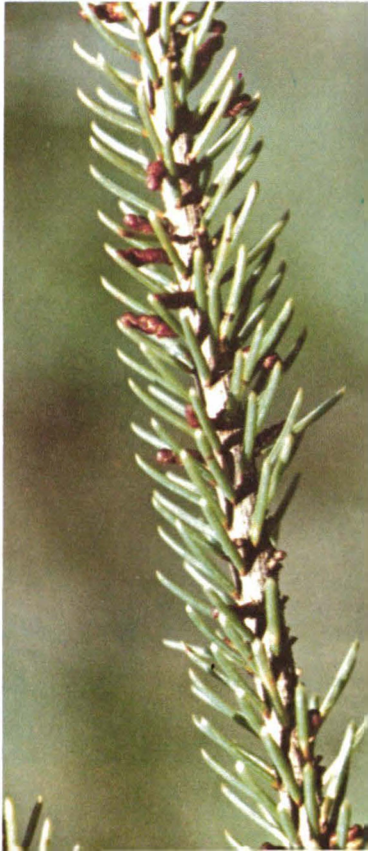
Dwarf mistletoe, *Arceuthobium pusillum* (the only species of dwarf mistletoe found in the eastern United States), is a native parasitic plant found on black spruce and occasionally on red spruce, white spruce, and tamarack. The organism causes swelling of the branches and masses of twigs, sometimes leading to formation of witches' brooms, which may grow to be several feet in diameter. Several brooms can sap so much of the tree's vigor that it dies.

Mistletoes reproduce by means of seeds expelled from explosive fruits. The sticky seeds cling to needles, eventually sliding down the needles to germinate on twigs. During the first year, the parasite penetrates the wood with a root-like structure and develops food and water transport systems. An aerial fruiting structure arises in the early spring of the second year. The structure is green and about as long as the spruce needles. Male and female plants are located on separate branches or on separate trees. During the third year, pollen and flowers are produced. Male (pollen-producing) structures, which survive only a short time, are large and orange-yellow. Pollen is spread to the tiny flowers by wind, insects, and birds. Each flower then bears one barrel-shaped fruit. The fruit, which matures in the fall, is a hard seed covered with a sticky substance. The seed is shot out of the coat for a distance of up to 30 feet, as pressure forces both seed and coat from the fruiting structure. The fruiting structure then withers and falls off, leaving only the cup-shaped base. Seeds may also be carried on the feathers of birds and the fur of squirrels.

▼ Witches' brooms (larch)



▼ Fruiting structures



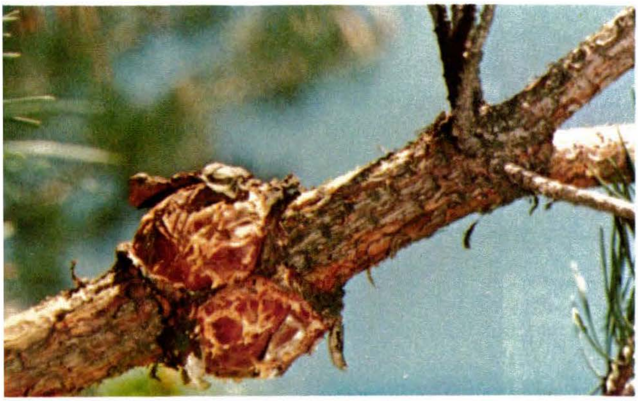
EASTERN AND WESTERN GALL RUSTS

Eastern gall rust (*Cronartium quercuum*) and western gall rust (*Endocronartium harknessii*) are fungi that cause the formation of round galls on the branches and stems of hard pines. Eastern gall rust requires oak as an alternate host, while western gall rust requires no alternate host. The diseases commonly attack jack, Scots, and shortleaf pines in the northeastern United States.

Eastern gall rust is found throughout the eastern United States. Western gall rust is found in both western and eastern United States. The only certain way to distinguish eastern from western gall rust is through laboratory culturing. These gall rusts are important primarily in the Lake States. The diseases can kill small trees and losses may be severe in nurseries, young forest stands, and Christmas tree plantations. In older stands, trees with trunk infections may develop decay and can be broken off easily by wind.

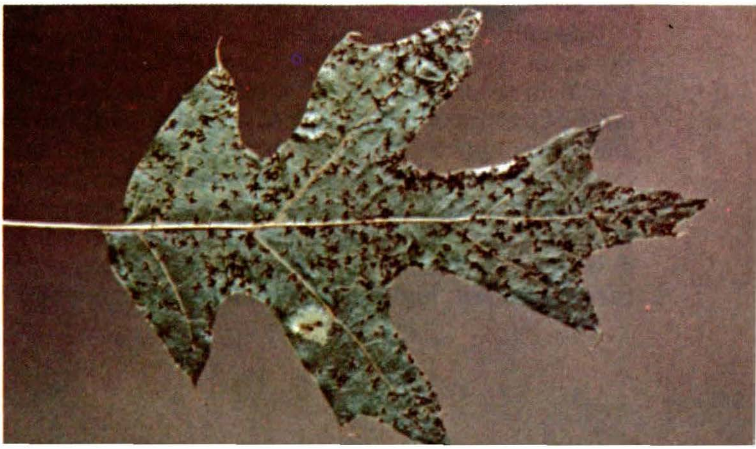
Infection on pines begins in the current year's shoot. A year later, a round swelling develops at the point of infection; it enlarges annually, and may eventually attain a diameter of 6 inches or larger. In the spring about 4 years after infection, the surface of the gall cracks, revealing large blister-like structures. Orange aeciospores are released from the gall for several years.

Infections on oak leaves (eastern gall rust) begin as dark brown spots. Uredia and later telia eventually develop on the undersides of the leaves. Telia mature by early or mid-summer.



◀ **Aecia on Scots pine — eastern gall rust**

Infected oak leaf ▶

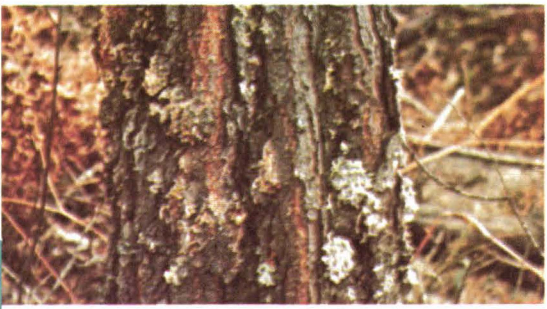


SWEET FERN, STALACTIFORM, AND COMANDRA RUSTS

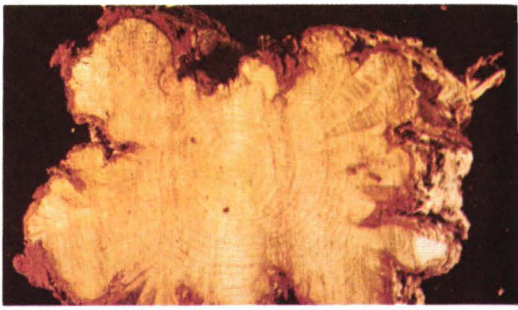
Sweet fern rust (*Cronartium comptoniae*), stalactiform rust (*Cronartium coleosporioides*), and Comandra rust (*Cronartium comandrae*) are diseases of hard pines. Sweet fern rust is found in the northern United States, stalactiform rust occurs in the West and the Lake States, and Comandra rust is found in the West, Lake States, and South. These rusts may kill the tree outright or make it more susceptible to insects, decay, and wind breakage. The lumber cut from infected trees may be of low quality.

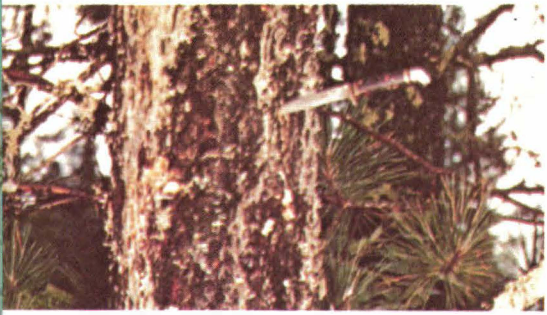
All three rusts require two hosts to complete their life cycles. The primary hosts of sweet fern rust are jack, Scots, lodgepole, ponderosa, pitch, and other hard pines. Sweet fern and sweetgale are the alternate hosts. Stalactiform rust infects jack, lodgepole, Jeffrey, and ponderosa pines. Cow-wheat, Indian paint brush, lousewort, and yellow-rattle are the alternate hosts. Comandra rust causes galls on jack, Scots, lodgepole, ponderosa, loblolly, and other hard pines. Bastard toadflax and northern Comandra are the alternate hosts.

Diseased tree-sweet fern rust

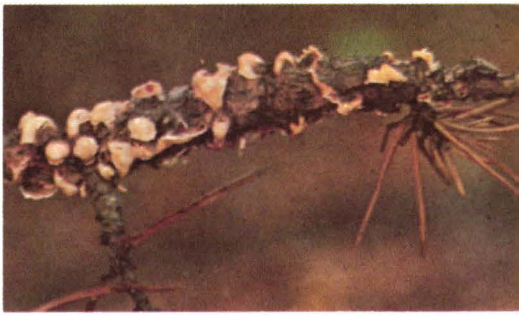


Cross section of diseased tree — sweet fern rust





Stalactiform rust



Aecia of commandra rust

Infection begins in the needles, and the fungus eventually moves into the stem. The sweet fern rust usually causes long swellings on the stems 1 to 2 years after infection. Aecia with orange-yellow spores are produced on the swellings in the early spring. Stalactiform rust produces a spindle-shaped canker that is difficult to distinguish from sweet fern rust in the initial stages. Several years after infection, long diamond-shaped cankers form on the main stem of the host. Aecia are produced at the margins of the cankers. Comandra rust causes elongated, slight swellings at the point of infection. The older cankers become cracked and pitted, are rarely swollen, and produce orange-red aeciospores in early spring.

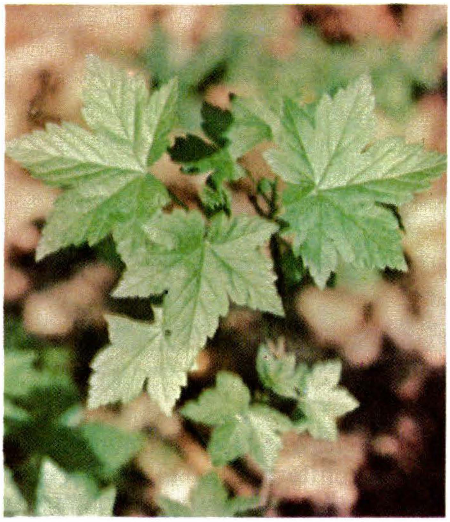
WHITE PINE BLISTER RUST

White pine blister rust, caused by *Cronartium ribicola,* is the most serious disease of eastern white pine. The fungus completes two of its five spore stages in the bark of pines and three stages on the leaves of certain plants of the genus *Ribes* (gooseberries and currants).

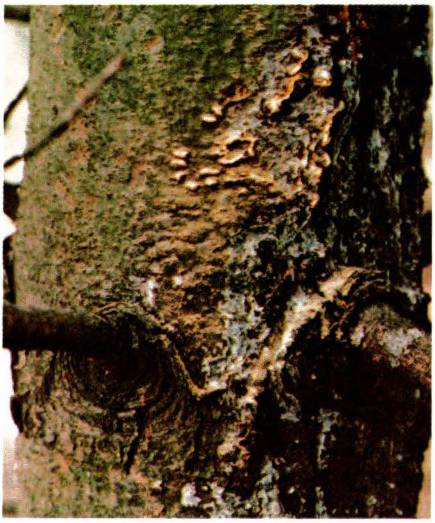
The fungus infection in pine begins in the needles, then spreads into the stems and branches. Trees are ultimately killed by trunk infections, which usually come from branch infections. Not all branch infections reach the trunk; many die after the branch is killed.

During the first or second season after the tree is infected, the diseased bark becomes yellow to orange and the stem swells and blisters. The blisters soon burst, releasing spores (pycniospores). The scars from the blisters remain. One more season passes, and the following spring aecia appear near or in the scars. The aecia are white blisters that soon rupture to release orange-yellow aeciospores, which can infect *Ribes* leaves as far as 200 miles away. Aecia are produced each year until the tree dies.

▼ ***Ribes*** **plant**

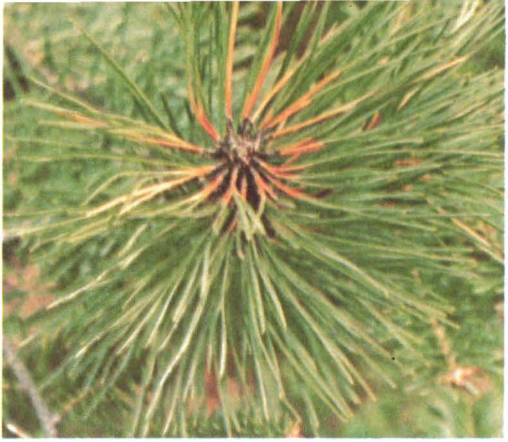


▼ **Aecia**

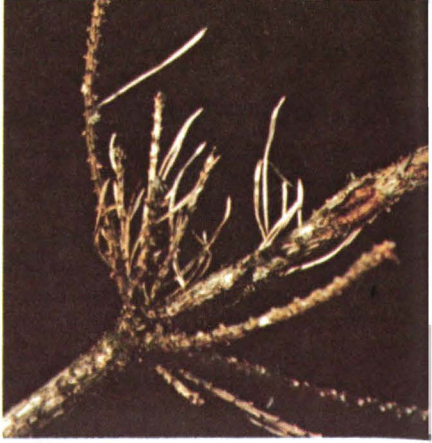


About 2 weeks after the *Ribes* leaves are infected, uredia form on the undersides of the leaves. Uredia produce urediospores, which carry the fungus from *Ribes* to *Ribes*. Individual urediospores are wind-borne only short distances. However, because spore production and infection may be repeated up to seven times in a single summer, this means of spread is quite effective.

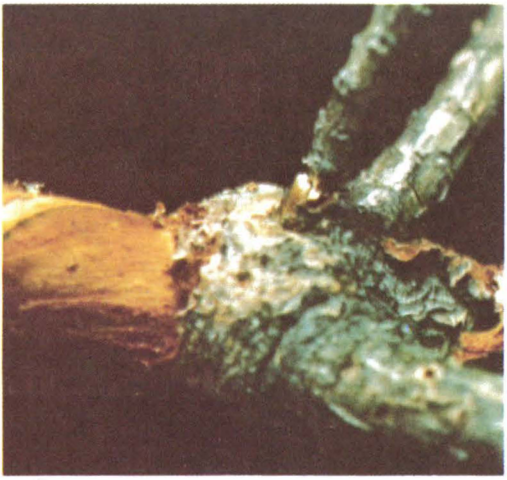
In late summer or early fall, telia appear on the undersides of *Ribes* leaves. They resemble slender, brown bristles, and are often so abundant that they form a felt-like mat. The telia produce teliospores, which in turn germinate to form structures called promycelia. The promycelium produces the spores that infect pines. The spores can infect pines no farther than a mile from the *Ribes* plant, and weather conditions must be moist and cool. Most infections occur close to the ground, where the most humid and coolest air is found.



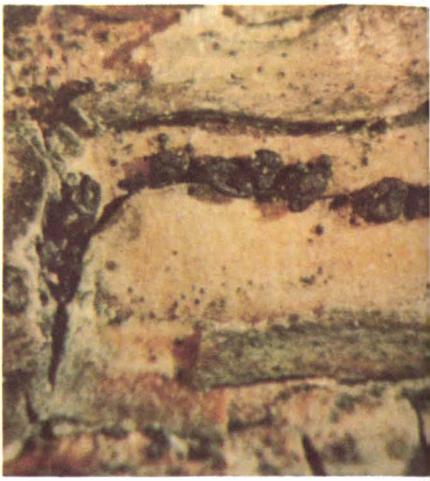
▲ Orange discoloration at base of needles



▲ Branch cankers



▲ Green stain

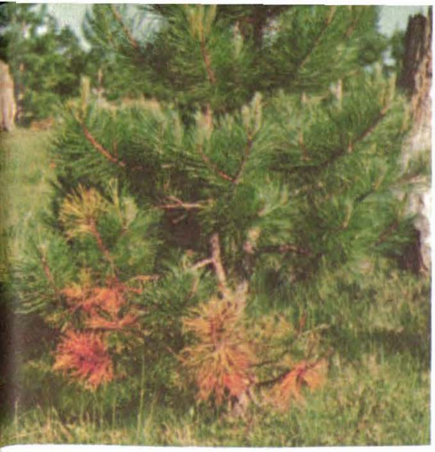


▲ Sexual stage

SCLERODERRIS CANKER

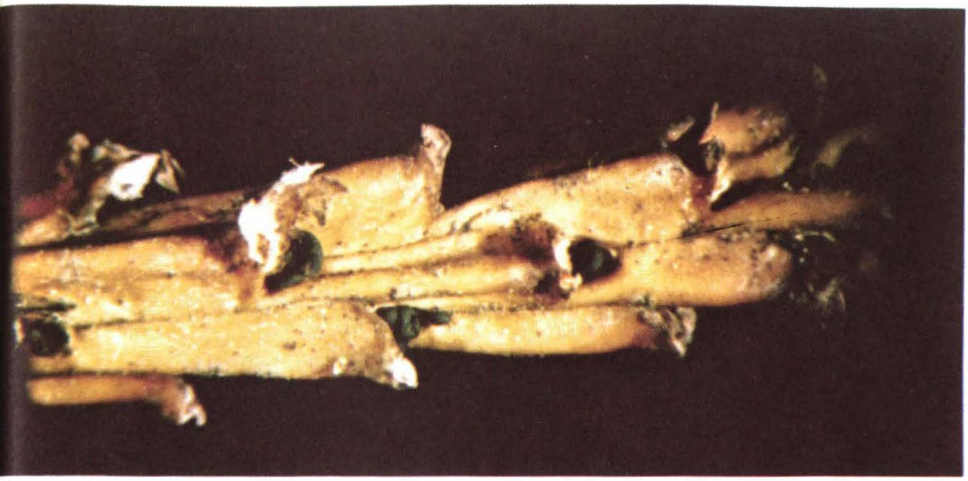
Scleroderris canker, caused by *Gremmeniella abietina* (formerly *Scleroderris lagerbergii*), is a serious disease of conifers. Hard pines are most susceptible; red, jack, and Scots pines are the species most commonly attacked. White pine and spruce are resistant, but may be attacked; balsam fir is immune. In the Lake States, the canker kills seedlings, small saplings, and the lower branches of larger pines. In New Hampshire, New York, and Vermont, where a more aggressive strain of the fungus is found, pines of all sizes are killed. The most severe damage occurs in depressions called "frost pockets," which may serve as reservoirs for large numbers of spores that infect trees in surrounding areas.

Because the fungus first attacks the buds and then progresses into the expanding shoots and needles, injury is most noticeable at the tips of branches. An early spring symptom is an orange discoloration at the base of the needles, a result of infection that occurred the previous summer. The needles then turn entirely orange and eventually brown. The dead needles drop readily, and bare dead shoots pointing skyward are a characteristic symptom. The fungus grows down the stem of the branch until it reaches the main stem, unless it is stopped when the branch dies. Main stems up to about 3 inches in diameter can be girdled or cankered. The tree also can be killed by the loss of foliage — this is the way the more



Low branch killing

Dying pines



Asexual stage

aggressive or "European" strain of Scleroderris most often kills trees. Small branch cankers, which are usually callused over, are common when the disease is caused by the European strain.

The most reliable symptom of Scleroderris canker is a green to yellow-green staining of the inner bark and wood beneath the bark of infected stems. The color is sometimes dull or even lacking, but among several infected branches there usually is one with a bright stain that resembles green ink.

G. abietina may produce both sexual and asexual spores. The fruiting bodies of both stages are very small, barely visible to the unaided eye. Fruiting bodies of the asexual stage are found most easily at the bases of the discolored (orange) or dead needles. Asexual fruiting bodies also form on bark. Spores of the asexual stage are spread by rain, usually infecting more branches of the tree on which they originated. The brown fruiting bodies of the sexual stage, when they form, appear on dead stems and needles. No sexual stage of the European strain has been found. The spores are released during wet weather. Sexual spores are dispersed by wind and can spread the disease considerable distances. Sexual spore production and infection take place in July or August, and symptoms appear the following spring.

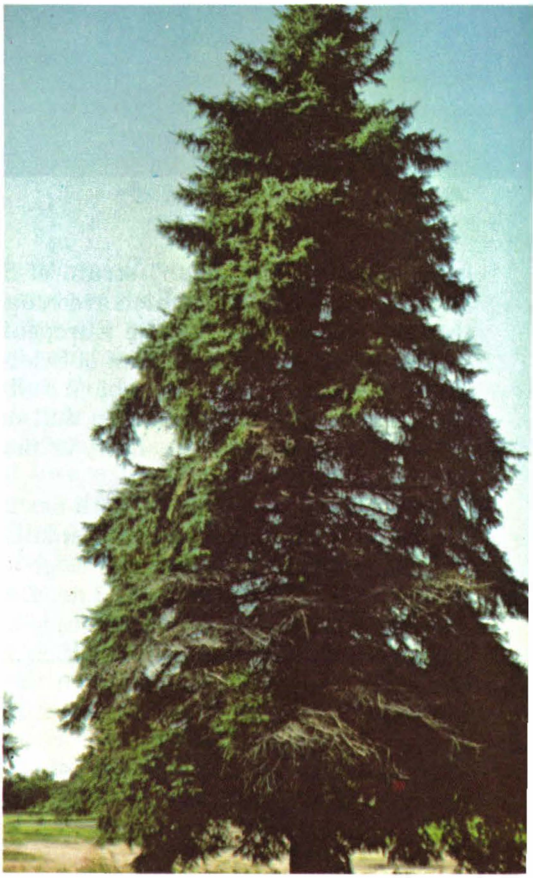
CYTOSPORA CANKER OF SPRUCE

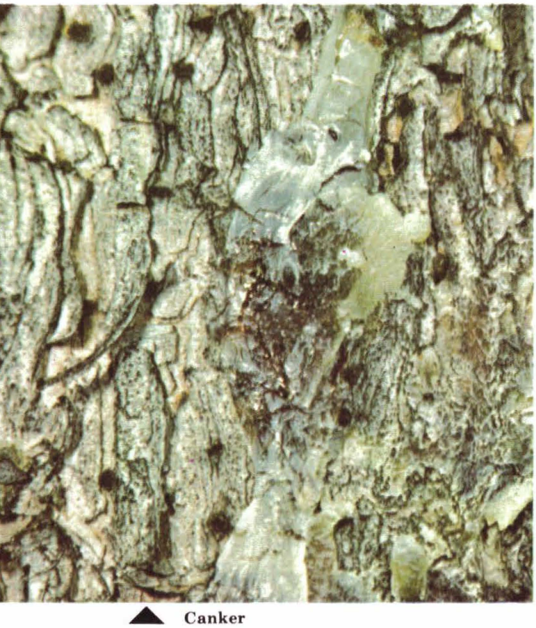
Cytospora canker of spruce is caused by the fungus *Cytospora kunzei*. The fungus is found most frequently on Norway and blue spruces, but also attacks white spruce, red spruce, Koster's blue spruce, and Douglas-fir. Branch cankers disfigure the trees, but rarely kill them. Trunk cankers, however, sometimes girdle and kill the trees. Cytospora canker sometimes attacks young trees, but it is more common in trees 15 years of age and older. Trees of low vigor, trees with shallow roots, those growing on unfavorable sites, and those weakened by drought, mechanical injury, or insects are more susceptible.

The first symptom of infection is usually the death of a lower branch and subsequent needle browning. As the disease progresses, infection spreads to higher branches. The cankers on infected branches are inconspicuous because the affected bark does not change color or become depressed. Infected areas may be covered by resin, which often drips onto lower branches. The removal of resin and outer bark from cankers reveals the brown, dead areas of inner bark and cambium.

Tiny, black, pinhead-like fruiting bodies of the fungus form in the areas of the bark where diseased tissue adjoins healthy tissue. During rainy weather, the threadlike, yellowish spore masses ooze from the fruiting bodies. The spores are spread by rain, wind, pruning tools, and possibly insects and birds. The spores infect through wounds.

Tree dieback ▶



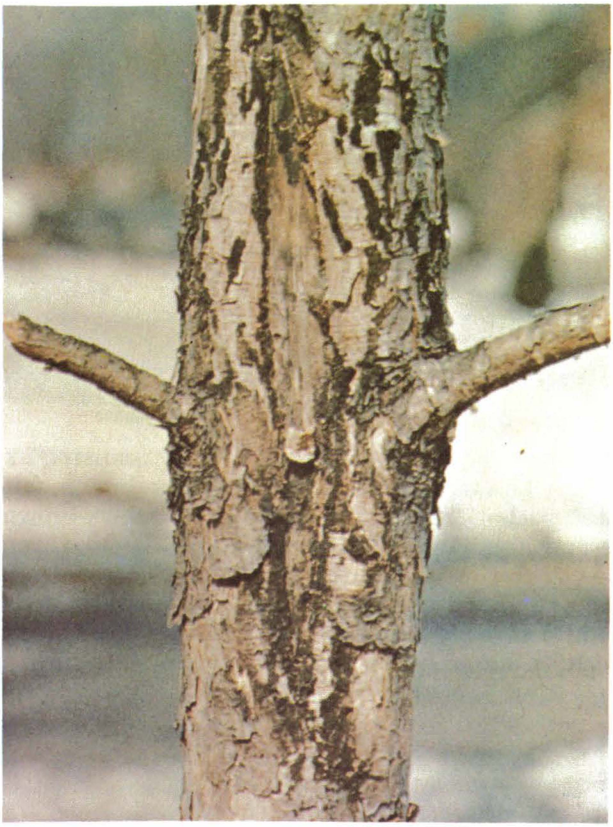


▲ **Canker**

TYMPANIS CANKER

The fungus *Tympanis confusa* causes a canker on red pine trees, but incidence is related to tree vigor. Only red pine planted outside its normal range is likely to be infected. Stands in need of thinning are susceptible, and drought can increase stand susceptibility. *T. confusa* kills few trees, but the fungus allows secondary decay fungi to enter the tree. Trees often break off at the site of the canker.

The fungus normally lives on dead material and enters through branches that have been killed by shading. Young cankers are difficult to see. After a few years, the bark sloughs off and exposes the pitch-soaked and dark-colored wood. Fruiting bodies of both the sexual and asexual stages form on the dead bark of cankers. The fruiting bodies are black and may be single or in groups.



◀ **Canker on red pine**

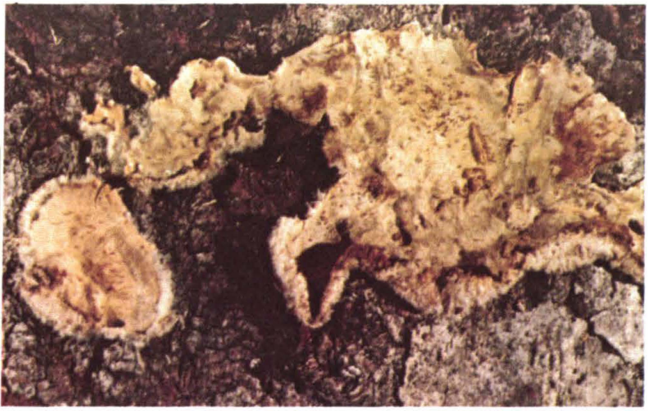
RED HEART OF FIR

Red heart of balsam fir, a trunk rot, is caused by the fungus *Haematostereum sanguinolentum* (formerly *Stereum sanguinolentum*). Norway spruce and white pine are also susceptible. The fungus decays heartwood in living trees, and both heartwood and sapwood in slash.

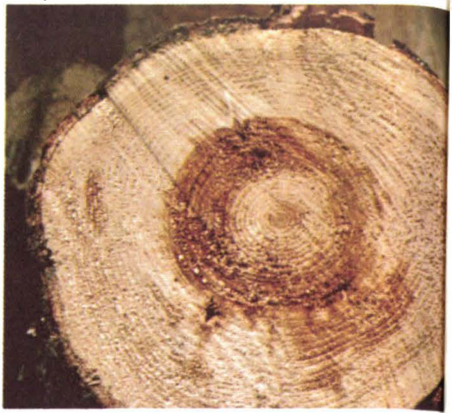
The fungus enters the tree through stem and branch wounds caused by winter storms, frost cracks, lightning, falling trees, logging, and insects. Invasion occurs within a year after the tree is wounded. At first the infected wood is reddish brown and appears water-soaked. As the decay progresses, the wood becomes yellow-brown, stringy, dry, and light in weight. The white fungal mycelium can be seen throughout the rotting wood. The rot rarely spreads down into the butt of the tree. Since the fungus fruits only on dead wood, defect due to this fungus in living trees often goes undetected.

The fruiting body is olive-colored, thin, leathery, and usually ½ to 2 inches wide. It lies flat against the wood except where it curls at the margins. The fruiting body exudes a red liquid when broken or crushed, hence the species name "sanguinolentum" (containing blood). Spores are produced on the smooth undersurface. The fruiting body produces spores for 1 year only.

▼ **Fruiting structure**



▼ **Cross section of diseased tree**

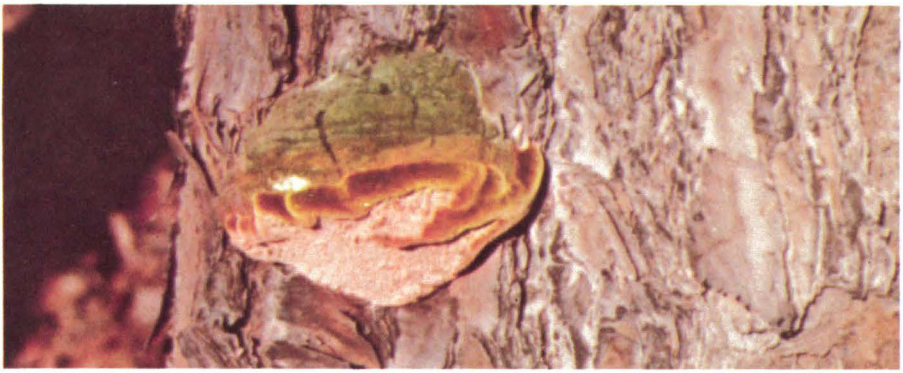


PHELLINUS PINI

Phellinus pini (formerly *Fomes pini*) attacks most conifers, causing extensive decay. The conk may be shelf-like or merely a yellow-brown, felt-like mass in a branch stub pocket. The shelf-like conk has a dark-brown, furrowed upper surface and a yellow-brown undersurface. Viewed from below, the pores may be circular or irregular.

In early stages of decay, the wood may be red, pink, or purplish. Spindle-shaped pockets of white mycelia accompanied by black flecks form later. Eventually the pockets merge into white felt mats.

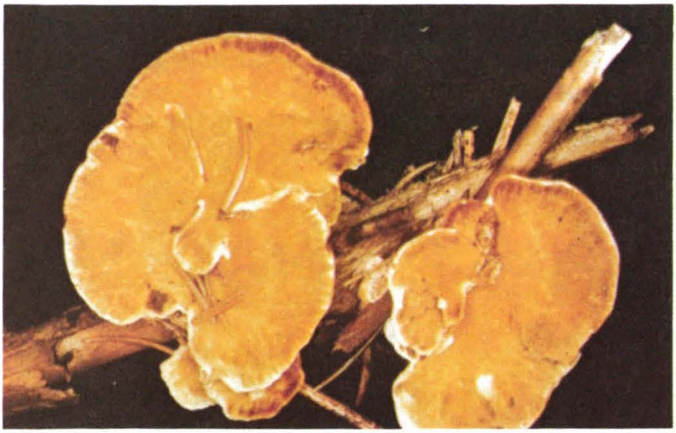
▼ **Conk**



INONOTUS TOMENTOSUS

Many conifers, especially eastern and western white pines and eastern spruces, are susceptible to *Inonotus tomentosus* (formerly *Polyporus tomentosus*). The fungus causes a butt rot, but decay may extend 10 feet up the bole. Infected wood contains white pockets of rot surrounded by brown or reddish sound tissue, giving ends of the logs or roots a honeycombed appearance.

The fruiting body is found on the ground near the base of the infected tree or occasionally on the base. It is 1 to 2 inches wide with a yellow-brown center and a white border. It is on a thick stalk, and the pores on the undersurface may extend partially down the stalk.



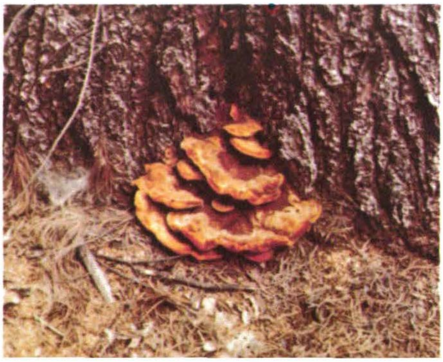
◀ **Fruiting bodies**

PHAEOLUS SCHWEINITZII

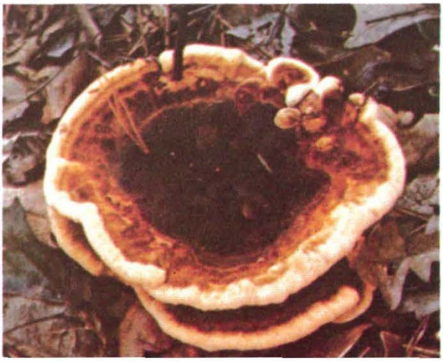
Phaeolus schweinitzii (formerly *Polyporous schweinitzii*) causes the most serious butt rot of conifers in the United States. Douglas-fir, pines, and spruces are most often affected. *P. schweinitzii* produces a dark-reddish-brown rot. In advanced stages, the wood crumbles when handled. Though the fungus causes primarily a butt rot, decay may extend to 10 feet above the ground.

The conk usually is found at the tree base or on the ground near the tree. At the tree base, the conk is associated with a wound and forms a thin shelf. When on the ground, the conk has a short stem. The upper surface of the conk is a velvety, dark reddish brown and the undersurface a yellow-green. The pores are large and irregular.

▼ **Conk at base of tree**



▼ **Ground conk**

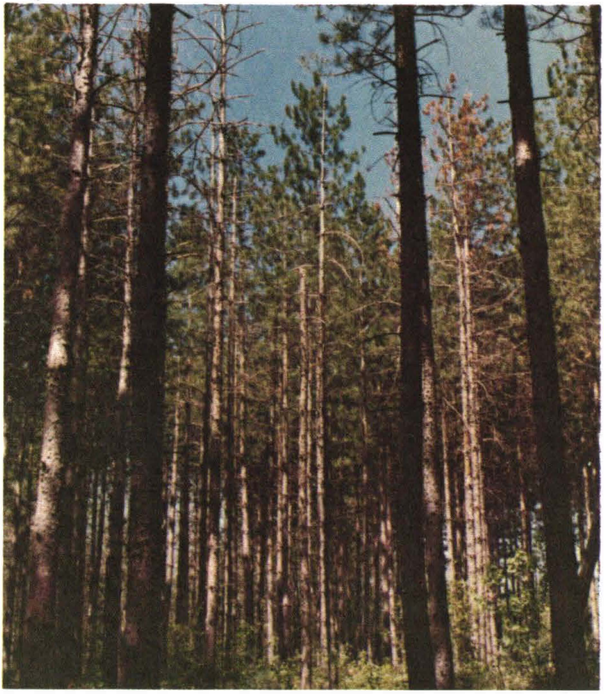


ANNOSUS ROOT ROT

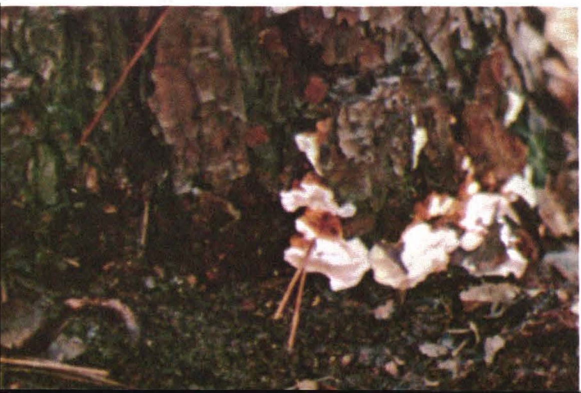
Most conifers are susceptible to attack by the root pathogen *Heterobasidion annosum,* formerly called *Fomes annosus.* In the northeastern United States, damage is most serious on red, white, loblolly, and shortleaf pines. When small pockets of dead or windthrown trees appear in a plantation that was thinned 2 or 3 years previously, the trouble is likely to have been caused by annosus root rot. The crown of live but infected trees may be thin and the foliage lighter than normal.

The reproductive structures (conks) may be found on the roots of windthrown trees or beneath the decaying needles at the bases of infected trees or stumps. The conks are tough, leathery, brown on the top, and white and porous on the bottom. They are irregular in shape and range in size from small buttons to brackets 6 inches wide. Airborne spores from these conks will infect stumps of recently cut trees. The fungus will rot the stump and then spread to nearby living trees through root grafts.

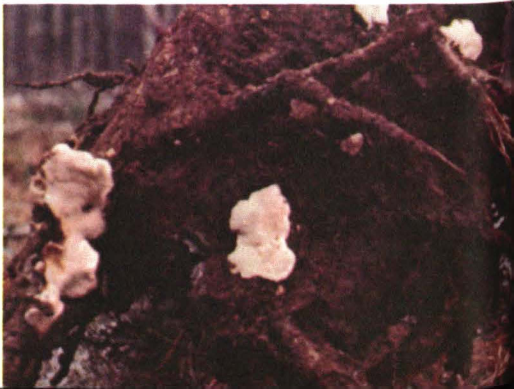
▼ **Pocket of dead trees**



▼ **Fruiting bodies**



▼ **Conks on root of windthrown tree**

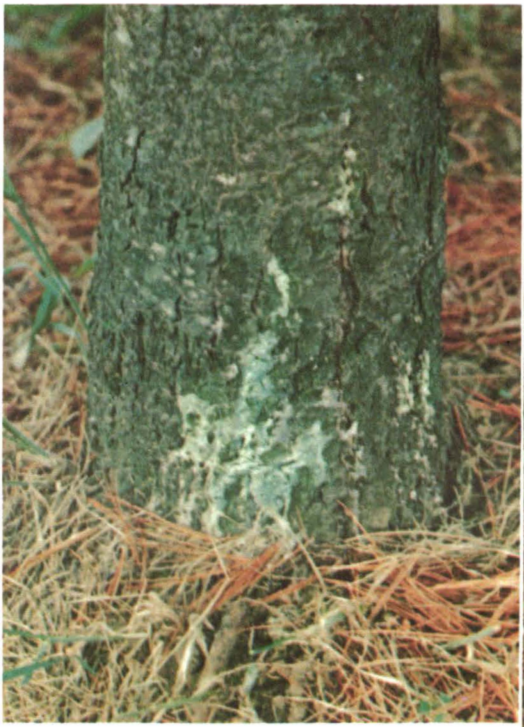


WHITE PINE ROOT DECLINE

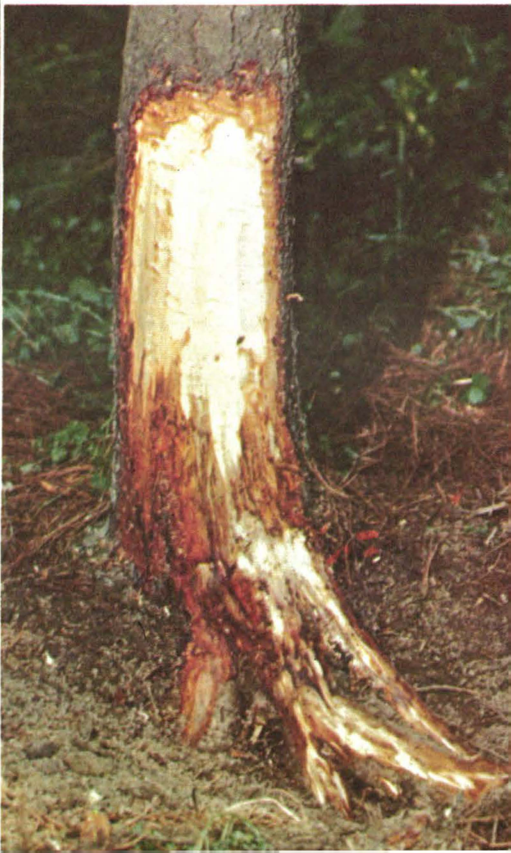
White pine root decline is caused by the fungus *Verticicladiella procera*. The fungus has been found in jack pine and red pine as well as in eastern white pine, and has been reported from Montana, Ohio, Indiana, Maryland, Pennsylvania, West Virginia, and Vermont. Trees of all ages are attacked and, usually after several years, killed.

One of the first symptoms of root decline of eastern white pine is a marked delay in bud break. When the buds finally break, the candles elongate and the shoots extend more slowly than normal. At the same time or soon afterward, the foliage turns yellowish and wilts. Foliage then changes from a tannish to reddish-brown color, and dead needles remain attached indefinitely. Cankers, found on the root collar, may extend from the ground line to 18 inches up the trunk. The trunk is not distorted. Removing the outer bark over the canker reveals an uneven chocolate-brown to olive-brown stain in the cambium area.

Very little is known about the disease cycle or manner of spread of this fungus. A species of *Verticicladiella* found in the West is thought to be spread by a bark beetle (*Hylastes macer*); *V. procera* may also be spread in this manner.



◀ **Canker**



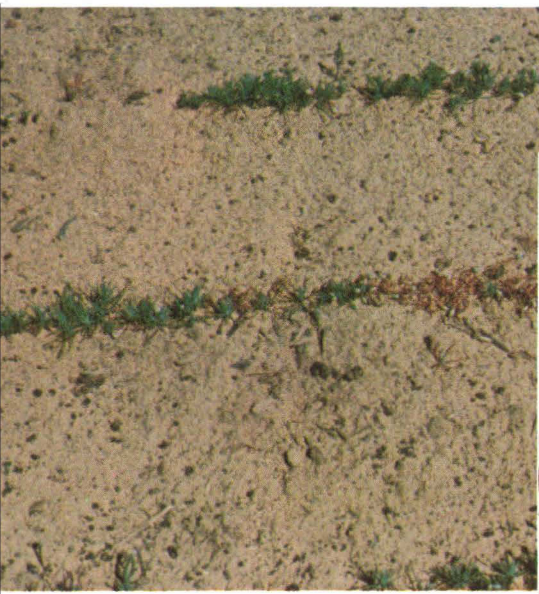
Canker and associated stain ▶

DAMPING-OFF

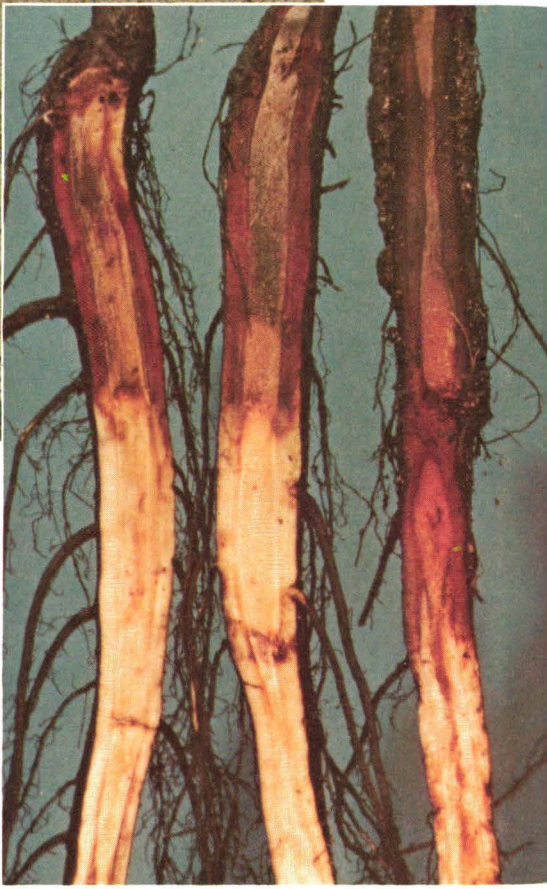
Seedlings of all conifers except junipers are susceptible to damping-off. Many hardwoods also are susceptible, especially elm, sweet gum, sycamore, yellow-poplar, and Russian olive.

The fungi that cause damping-off, *Rhizoctonia solani* and species of *Pythium, Fusarium,* and *Phytophthora,* produce hardy spores or other structures that rest in the soil until conditions are suitable for germination. Damping-off is common in nurseries, where spore concentrations build up. Excessively wet and alkaline soils (pH above 5.5) provide ideal conditions for germination, growth, and movement of fungi through the soil to host seedlings.

A seedling may be infected and killed before it can break the surface of the ground (pre-emergence damping-off). Usually, though, the seedling emerges and the pathogen then rots the stem at ground level.



▲ **Affected trees in nursery bed**

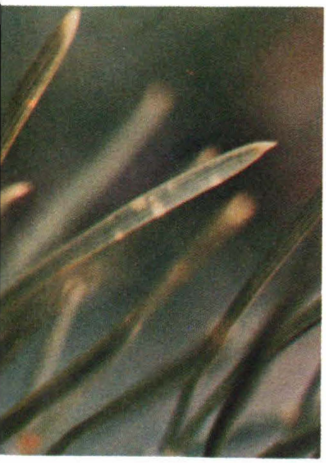


Root decay caused by ▶
Phytophthora

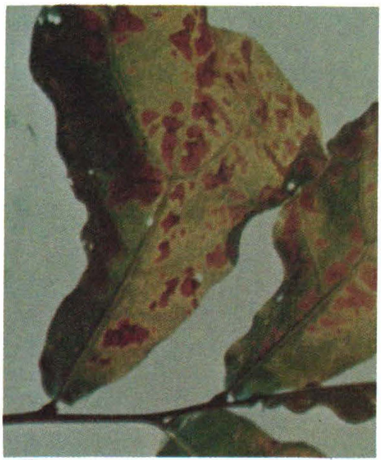
AIR POLLUTION

Several air pollutants will injure trees: oxidants, sulfur oxides, and fluorides are the most common. Most of the oxidants resulting from use of internal combustion engines originate in urban areas, but the wind may carry them to remote rural areas. Lightning may create ozone. These pollution sources are called "nonpoint" sources, and injury to plants may occur nearly anywhere. Other pollutants, such as sulfur oxides, fluorides, and some particulates, are generated from a single point (a power plant, chemical factory, smelter, etc.). Usually only the areas immediately downwind from these sources are subjected to high levels of pollutants.

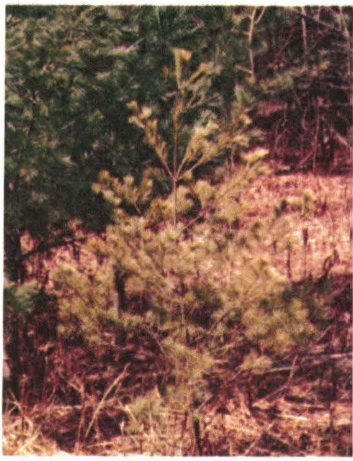
Oxidant injury to broadleaved trees is distributed uniformly. A mottled or blotched appearance, bronzing, and shiny undersurfaces on some leaves are typical symptoms. Damage from salts, fluoride, and sulfur dioxide is normally confined to sharply defined areas. In the case of sulfur dioxide, injury is usually between the veins of leaves. For some salts and fluoride, injury occurs along the leaf margins.



▲ SO_2 injury to conifer (mottling)



▲ SO_2 injury on hardwood leaves



▲ Dwarfed and chlorotic tree caused by air pollution

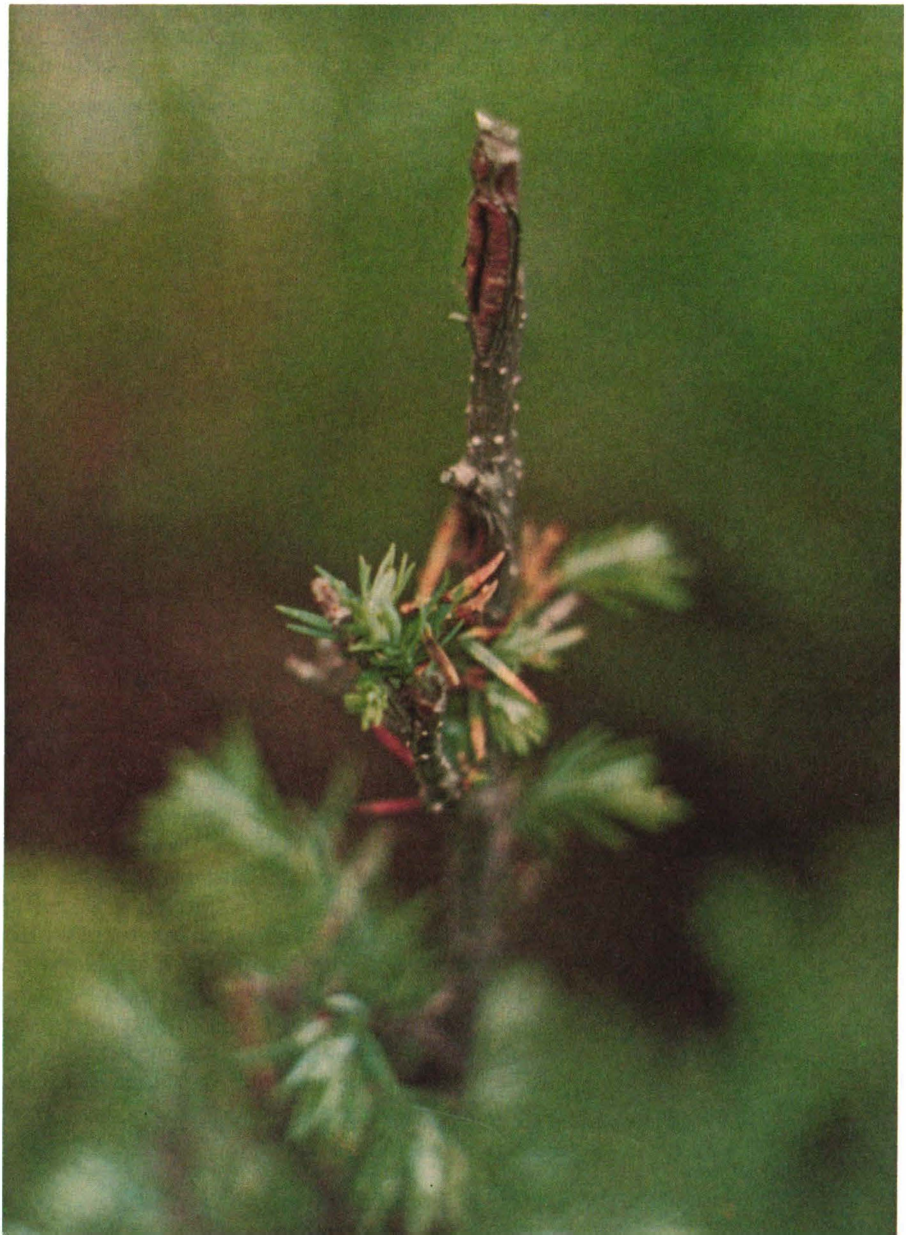
Oxidant injury to conifers is usually uniformly distributed, and often causes a general reduction in growth. Mottling is typical of ozone injury. Eastern white pine is particularly susceptible to ozone, which may even cause dwarfism in some genetic types. Some pollutants, such as sulfur dioxide and fluoride, cause needle tips to turn brown. Needles injured by fluoride may have a dark band between the living and dead tissue.

Although trees within a species vary somewhat in their susceptibility to air pollutants because of genetic and environmental factors, species responses are generally predictable. The following are sensitive to sulfur dioxide: most species of birch; larch; and red, jack, and eastern white pines. Tolerant species include: northern white cedar; juniper; Norway, silver, and sugar maples; red and pin oaks; and blue spruce. The following are considered sensitive to ozone: ash; aspen; honey locust; mountain-ash; white oak; Austrian, jack, loblolly, ponderosa, and Virginia pines; yellow-poplar; and American sycamore. Tolerant species include: Norway, blue, and white spruces; and black walnut.

DEER BROWSING

Deer browsing is a serious problem in many areas of the eastern United States. Feeding is often so severe that it virtually eliminates all regeneration in clearcut areas. Cherry, sugar maple, and aspen are among the species most heavily browsed, but other hardwoods as well as conifers are utilized. Browsed trees usually exhibit ragged, torn shoots and terminals. Where damage is old, cankers and lesions often develop beneath the browsed area. More deer browsing can be tolerated when abundant regeneration is present prior to harvest of mature trees. Where timber values are high, fencing may be economical.

▼ **Damaged tree**



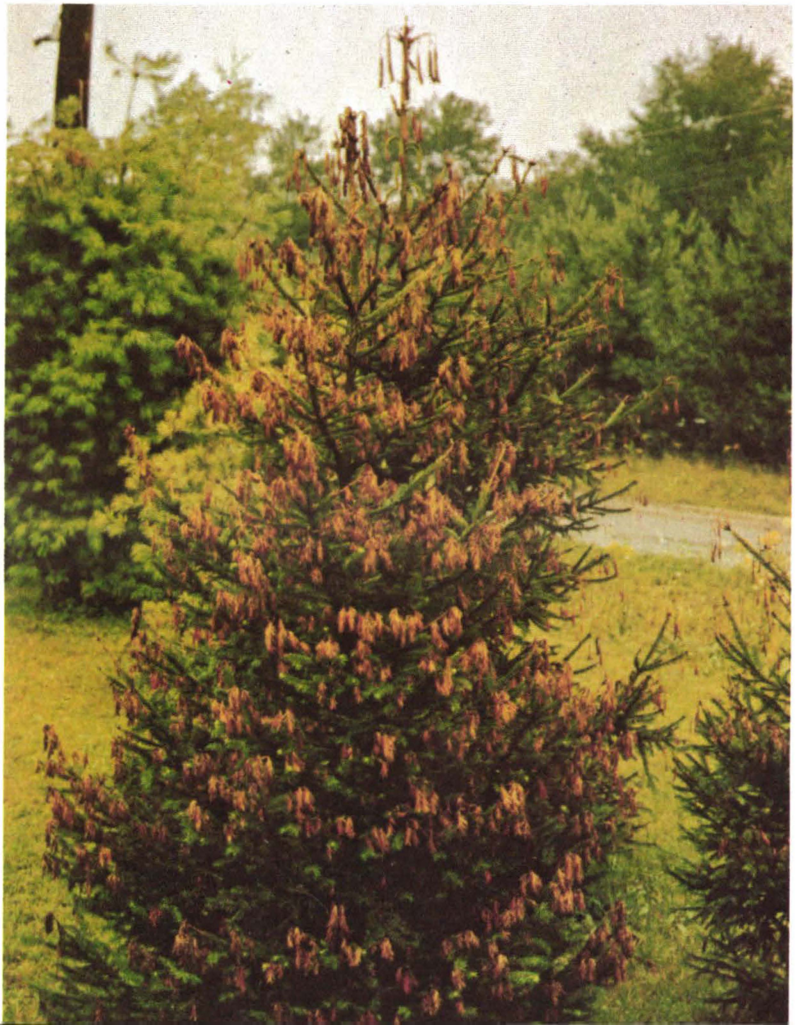
FROST INJURY

Most frost damage occurs in the spring after shoots and leaves have begun to grow. Trees growing at the northern limits of their species range are more frequently damaged.

On conifers, late spring frosts kill newly developing shoots. The damage appears similar to that caused by shoot borers. Frost usually kills most of the upper-crown shoots on the tree, and certain patches or blocks of trees within the stand tend to be more severely damaged than others. Young conifers are more likely to be damaged by frost than older trees. Damage results in excessive branching and rounded tree crowns.

Frost damage to hardwoods is usually confined to the succulent new leaves, which may die, turn black, shrivel, and eventually drop. Older leaves are damaged along the edges. Partially damaged leaves turn brown at the frosted margins and stay on the tree during the summer. This damage may be confused with leaf-roller injury. Late spring defoliation of hardwoods usually does not cause tree mortality, unless it is followed by other defoliation or drought. Tree mortality may occur from secondary insect and disease pests.

▼ **Frost injury on spruce**

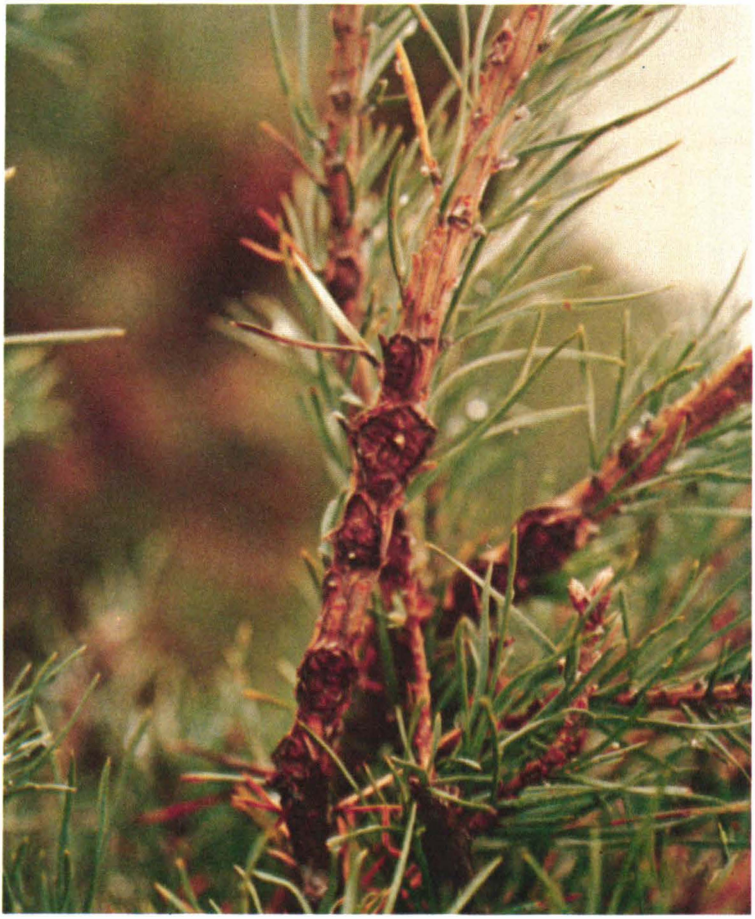


HAIL INJURY

Hailstorms can cause several levels and types of damage, from wounding of the bark and cambium to death of young trees and sprouts. The degree of damage depends on severity of the storm, size of the hailstones, and time of year. Conifer shoot breakage or laceration of hardwood leaves may sharply check tree growth. Severe bruising or breaking of the bark and cambium may create entry points for wood decay fungi and insects. Younger stems with tender bark or trees with developing foliage in early spring are most seriously damaged.

Trees with flexible stems and tender bark, such as eastern white pine, are especially susceptible to hail damage.

▼ **Hail injury**

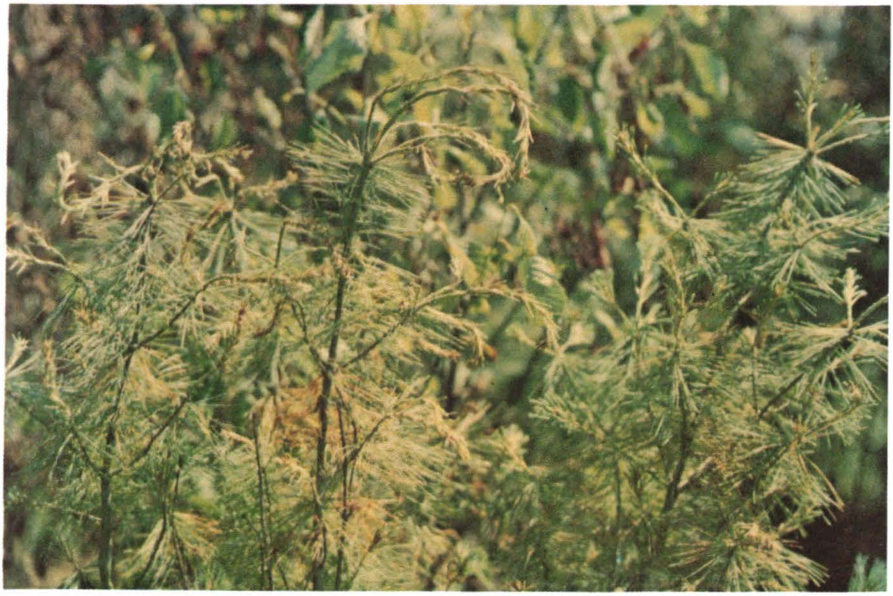


HERBICIDE INJURY

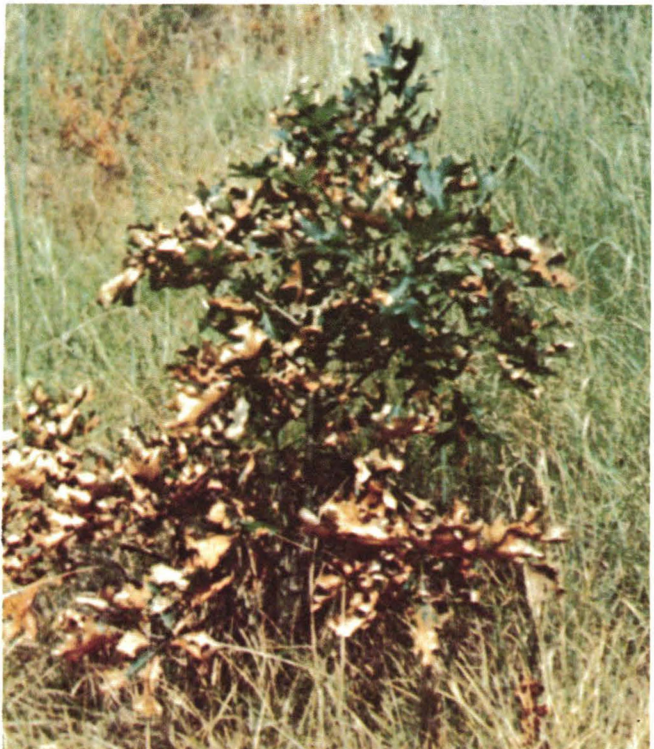
Herbicide injury can exhibit a variety of symptoms, depending on the type of herbicide, the concentration that reaches the tree, the temperature, and other factors. The most common symptom is distortion of leaves and twigs. Leaves become cupped and curled and often appear wilted.

Ornamental trees may be damaged by overapplication of "weed and feed" fertilizers, most of which contain 2,4-D. Deciduous trees are damaged more often than conifers, but less pronounced "distortion" does occur on pines as well. Aerially applied herbicides are often used to release pines from an overstory of undesirable brush and hardwoods. When viewed from the air this resembles a burned area, but with more regular boundaries.

▼ **Herbicide injury (pine)**



Herbicide injury (hardwood) ▶

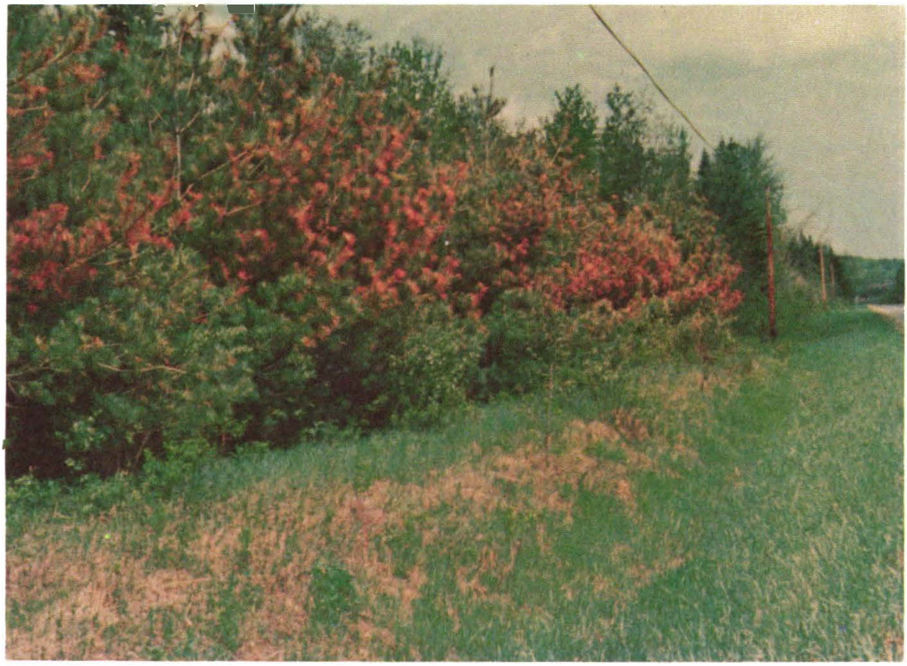


SALT INJURY

Although no tree is immune to salt injury, some can withstand higher concentrations than others. Most damage is to the foliage, but eventually the roots may be killed. In the northeastern United States, damage stems primarily from salt applied to streets and highways during snow and ice storms. Calcium-based salts are less damaging than sodium salts, but they are more costly and thus not as widely used. Trace elements within the salt, such as bromine, can reduce the degree of tree resistance to other pests.

Salt injury lowers the cold-hardiness of several species. Also, tree species subject to winter injury are generally more susceptible to salt injury than cold-hardy species. Trees planted north of their natural ranges therefore are more likely to be injured. Some trees resistant to salt injury are black locust, honey locust, ponderosa pine, green ash, mulberry, Japanese black pine, and eastern red-cedar. Some trees quite susceptible are white pine, sugar maple, red maple, larch, cottonwood, aspen, basswood, black walnut, red pine, hemlock, balsam fir, northern white cedar, beech, and white spruce.

▼ Salt injury

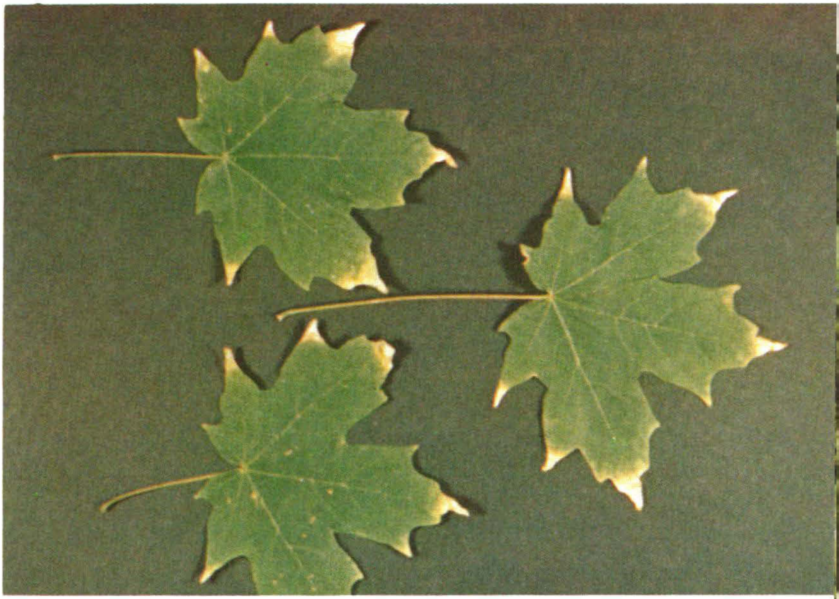


SCORCH

Leaf scorch results when a tree loses more water through transpiration than it can take in through the roots. The reduced water supply might be caused by drought, a pavement over the root system, or the use of salt for snow removal. All trees are susceptible, but maple and oak are affected more often than other species. Conifer seedlings in nurseries are sometimes injured.

Scorch symptoms vary from browning along leaf margins or veins to wilting and browning of the entire leaf. Usually the side of the tree facing the prevailing wind is affected most severely. Watering and fertilization (for ornamentals) may help prevent scorch.

▼ **Affected leaves**



WIND DAMAGE

High local winds, tornadoes, or hurricanes may cause root spring, windthrow, and branch and trunk breakage. All trees are susceptible to wind damage, but those with shallow root systems are more susceptible to root spring and windthrow. In areas of extensive wind damage, rapid salvage of damaged timber helps to reduce financial losses and prevent pest buildup. In high risk areas, lighter cutting may reduce windthrow.

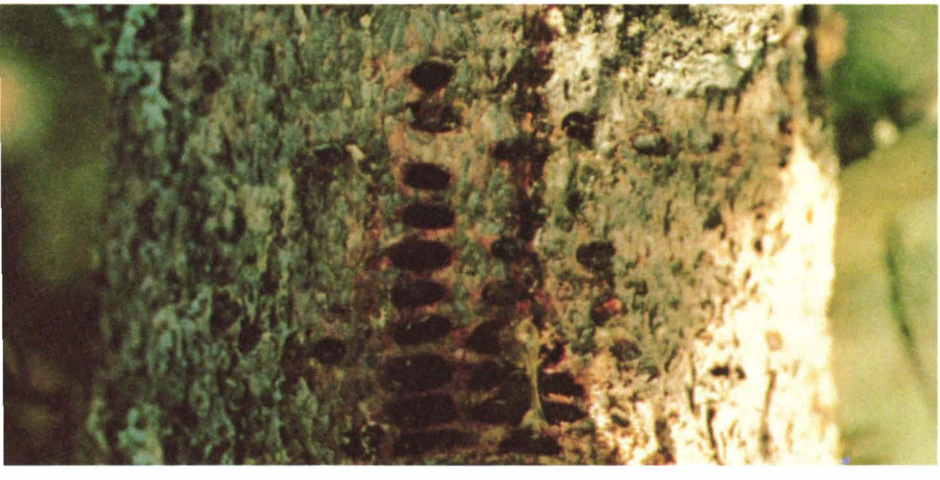
▼ **Windthrown trees**

SAPSUCKER DAMAGE

Sapsuckers, particularly the yellow-bellied sapsucker (*Sphyrapicus varius varius*) in the East, often injure or kill trees. These birds favor yellow birch, paper birch, hemlock, and aspen, but also damage other species. Sapsuckers drill small holes in the trees and drink the sap or feed it to their young. They nest in hollow trees (usually aspen) near their "orchards" and return again and again to favorite trees. When heavily drilled, a section of bark dies, and decay fungi can enter the tree. Sometimes the tree, or the top of the tree, is completely girdled and killed. Sapsucker holes cause defects in lumber and therefore lower its value. The injuries also lead to separation of the wood layers within the tree, a condition lumbermen call "shake."

▼ **Sapsucker**

▼ **Feeding injury**

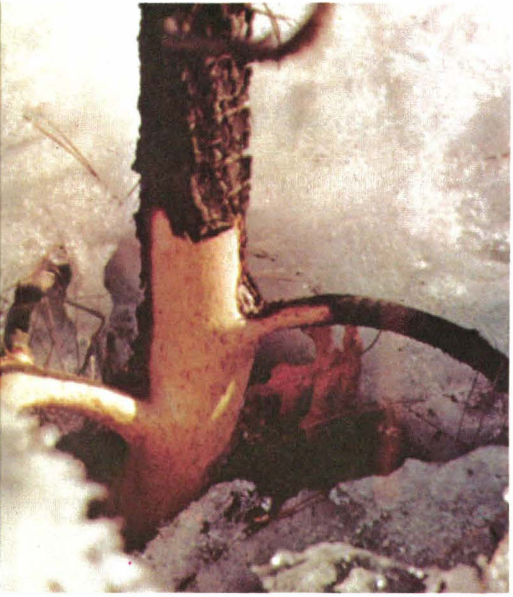


Sapsuckers are protected by law. Even if they were not, little is gained by killing them. Other sapsuckers lacking territories usually replace those killed. Removal of the nesting trees may be warranted where the birds are a serious problem, but usually the damage is not severe enough to justify the cost.

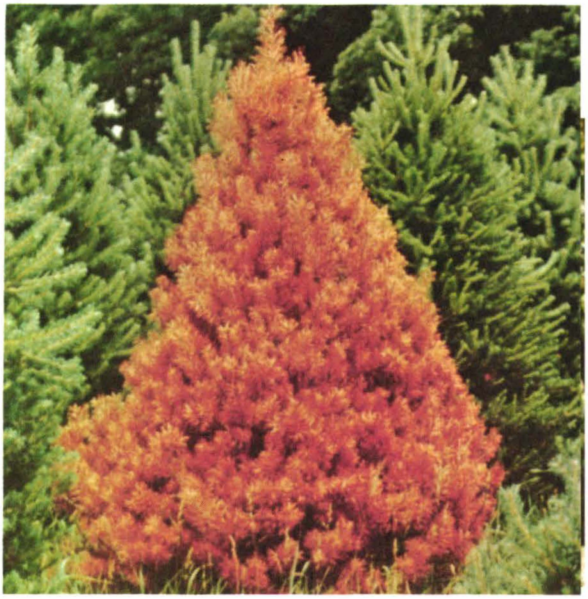
MOUSE DAMAGE

Mice sometimes cause serious damage in pine plantations, especially when winter snow cover is deep and food is scarce. They prefer areas with heavy weed or grass cover. Completely girdled trees may not show symptoms of injury until the following summer or fall.

▼ **Mouse damage**



▼ **Tree killed by mice**



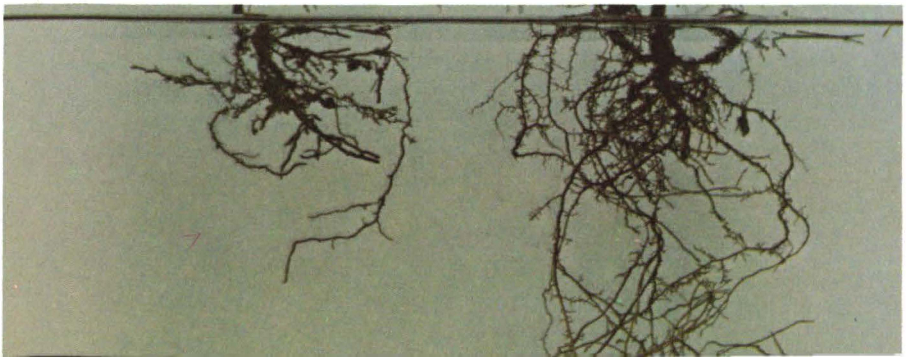
NEMATODES

Nematodes are thread-like worms so small they can be seen only with a microscope. Some are plant parasites which feed on the roots of trees. Parasitic nematodes are distributed widely and are found in forest nurseries throughout the United States.

Nematode diseases usually cannot be diagnosed by symptoms alone, because the symptoms resemble those of several other agents. Infested seedlings are low in vigor because they have small, distorted root systems, galls on the roots, and general decay of the feeder roots.

Nematodes often interact with fungi to form disease complexes. In addition, nematodes of the genera *Xiphinema* and *Longidorus* carry certain soil-borne viruses that infect tree seedlings.

▼ **Root systems — diseased (L) healthy (R)**



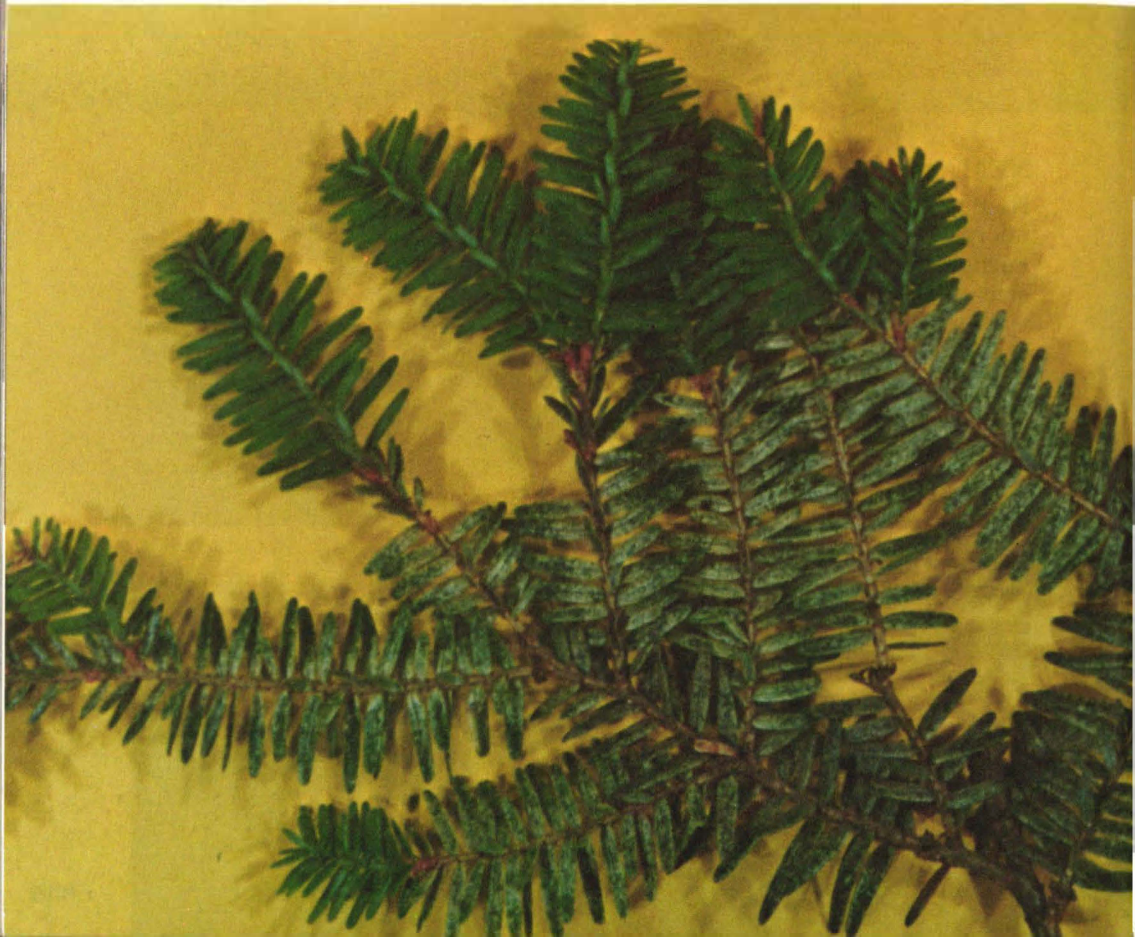
SPRUCE SPIDER MITE

The spruce spider mite, *Oligonychus ununguis,* attacks various conifers throughout the United States. Serious economic damage to hemlock, spruce, cedar, and occasionally pine has been recorded in nurseries, plantations, and ornamental plantings.

Heavily infested trees often have grayish to yellowish foliage, because the immature and adult mites feed by rupturing cells and sucking their contents. This results in needles with a characteristic mottled appearance. Extensive webs, which usually accompany feeding, collect dirt and dust to add further to the gray appearance of the foliage. When cool weather creates conditions favorable for population buildups, complete defoliation can occur.

Adult mites are less than 1⁄25 inch long. They are translucent, but appear yellow, green, orange, or red depending on the foods and wastes accumulated in their bodies. The eggs overwinter and hatch in late March or April. Many overlapping generations occur during the spring until dry, hot weather sets in. Reproduction drops off during the summer, and eggs remain dormant until the onset of cooler fall weather. Cold winter weather again creates unfavorable conditions for reproduction, and the eggs remain dormant until spring.

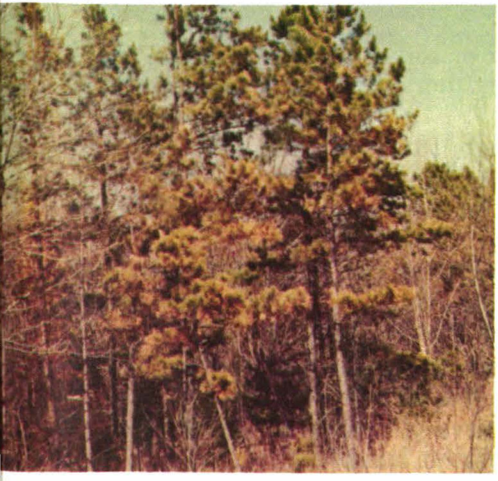
▼ **Spruce spider mite damage**



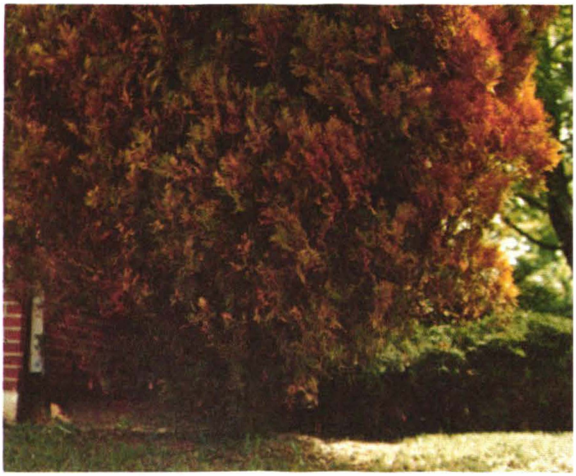
WINTER INJURY

Winter injury usually occurs in midwinter to early spring, generally over the entire tree above snow line. All conifers may be affected. The drying effect of the wind causes foliage to die and turn red. The foliage continues to give off moisture, but is unable to replace it from the frozen ground. This causes a drought condition within the tree until the ground thaws and soil moisture is available. Damage to ornamental plantings may be reduced or eliminated by covering trees during winter to protect them from high evaporation rates caused by wind.

▼ **Damaged tree**



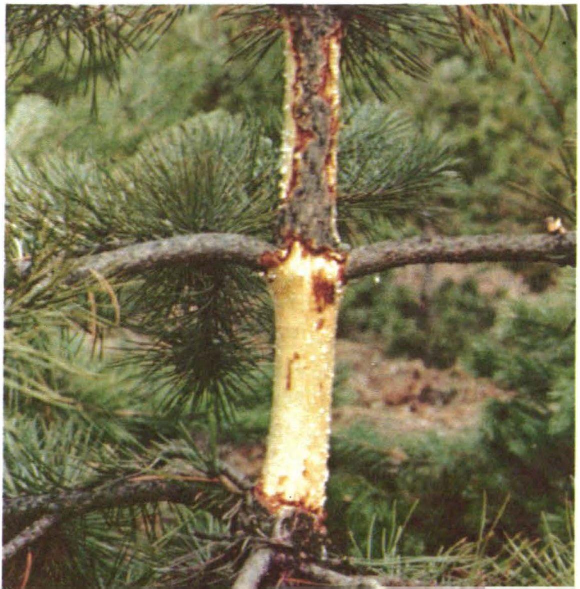
▼ **Damaged trees**



PORCUPINE DAMAGE

The porcupine, *Erethizon dorsatum*, can seriously injure or kill trees by eating the bark and sometimes girdling them. Porcupines eat herbs in the summer and tree bark in the winter when herbs are not available. Because trees may be killed above the feeding site, dead tops often result from porcupine feeding.

Feeding injury ▶



GLOSSARY OF TECHNICAL TERMS AND PHRASES

Abdomen	The third or posterior region of an insect body.
Aecium	A cuplike spore fruit, produced by certain rusts, in which chains of spores (aeciospores) are developed.
Ascospore	A sexually produced spore borne in an ascus.
Asexual	Produced vegetatively in plants; without union of sperm and egg in insects.
Basidium	A structure bearing on its surface a definite number of basidiospores formed by fungi in the class basidiomycetes.
Blight	Any atmospheric or soil condition, parasite, or insect that kills, withers, or checks the growth of plants.
Brood	All the individuals that are born alive or hatch from an egg mass or group of eggs deposited by one generation of parents and that mature within the same timespan.
Cambium	The thin layer of cells just beneath the bark of woody plants that gives rise to new cells and is therefore responsible for diameter growth.
Canker	A localized, often callused, malformation or area of dead tissue on a tree stem or branch.
Caterpillar	The worm-like larva of a butterfly or moth; also, any of various similar larvae.
Chlorosis	An abnormal yellowing of plant foliage.
Clone	A group of genetically identical individuals that have been produced by vegetative means from a single parent.
Cocoon	A protective case wherein an insect pupa is formed.
Conk	A type of reproductive (spore-forming) structure formed by certain fungi, usually wood rotters.
Defoliation	Loss of current year's or past years' foliage.
Dieback	The death of parts of a tree or plant usually from the top downward.
Dorsal	The top or uppermost side.
Duff	The partly decayed organic matter on the forest floor.
Frass	Anal excrement of an insect.
Fruiting body	A fungal organ specialized for producing spores.
Fungus	A non-flowering plant without chlorophyll that lives on either another organism (causing disease) or on dead organic matter.
Gall	A swelling of plant tissue caused by attack of insects or disease-causing organisms.
Generation	One complete cycle of the life history — i.e., egg through adult.

Grub	The larval form of beetles and wasps.
Heartwood	The older, non-living central portion of the tree bole that is usually darker and more durable than the surrounding sapwood.
Hibernaculum	A tent or sheath made out of a leaf or other material in which a larva hides or hibernates.
Host	An organism that serves as food, shelter, or resting site for an unrelated organism.
Larva	An immature form of some insect species that hatches from an egg and differs fundamentally in form from adults.
Lenticel	A bark structure that permits the passage of gas inward and outward.
Lesion	A wound or localized injury often expressed as broken outer bark tissue.
Looper	A larva of an inchworm or measuring worm.
Molt	The act of shedding the insect exoskeleton.
Mycelium	The vegetative (non-fruiting) portion of a fungus.
Mycoplasma	A type of disease-causing organism similar to a bacterium, but lacking a true cell wall.
Necrosis	Death of plant cells, usually resulting in darkening of affected tissue.
Nematode	A worm with a long, cylindrical, unsegmented body.
Nymph	A young insect which, when it emerges from the egg, resembles the adult but is smaller and has incompletely developed wings and sexual organs.
Oviposition	The act of depositing eggs.
Oxidants	A class of air pollutants that includes ozone and peroxyacetylnitrate (PAN).
Pathogen	A disease-causing organism.
Perithecium	A globular-shaped ascocarp with a pore at the top.
Petiole	The leaf stalk that attaches to the main twig.
Prepupa	The insect stage between the end of the larval stage and the beginning of the true pupal stage.
Proliferate	To grow by budding in quick succession.
Pupa	The resting, intermediate stage of insect development between the larval and adult stages.
Pustule	A small, sometimes colored, blister-like swelling.
Pycnidium	The spore case of certain fungi in which pycniospores are produced.
Rhizomorph	A thick strand of somatic hyphae in which the hyphae have lost their individuality.
Sapwood	The soft wood just beneath the bark of a tree.
Skeletonizer	A leaf-feeding insect that eats everything but the veins.

Sign	Any observable part of a pathogen.
Silviculture	The art of establishing, growing, and regenerating a forest.
Spore	Reproductive cell (or multiple cells) of a fungus or bacterium that serves the same purpose as the seed of higher plants.
Stipule	A modified leaf.
Symptom	Plant response to injury or infection.
Telium	A group of binucleate cells which produce teliospores.
Thorax	The second or intermediate region of an insect body that bears the true legs and wings.
Uredium	A group of binucleate cells which gives rise to uredospores, the repeating spores, of the rust fungi.
Witches' broom	An abnormal cluster of twigs and branches caused by certain pathogens.
Vector	An organism, often an insect, that transmits a disease from one host to another.

GUIDELINES FOR COLLECTING AND SHIPPING DISEASE AND INSECT SPECIMENS

Disease Specimens

Samples from diseased trees must often be sent to an authority for positive identification because (a) many diseases are not included in this guide, and (b) fruiting bodies or other signs of a pathogen may not be present when tree injury is seen. In the latter case, the pathogen must be isolated from other organisms and cultured in a laboratory. The following procedures should be used in collecting and shipping disease specimens.

Samples should be collected from the most recently infected part of the tree — that is, when foliage damage is present, the leaves or needles and twigs should be collected; when root damage is present, sections of root should be extracted; when a wilt fungus is suspected, a section of the trunk or stem should be removed, etc. Whenever possible, a sample should contain portions of both live and dead material.

Because most pathogens die when samples dry out, making culturing impossible, precautions should be taken to prevent drying during shipment. Slightly moist paper towels will help keep the inside of a mailing tube humid. Plastic bags or wax paper wrappings are suitable for most specimens. First class mailing is preferable.

Insect Specimens

Insects must be killed and preserved before shipping — *they must never be shipped live*. Beetles and larvae can be killed by placing them directly in alcohol. Large specimens should be placed in boiling water and allowed to cool gradually before they are placed in alcohol. Moths, butterflies, and large adult insects (other than beetles) should not be put in alcohol, because alcohol will destroy some of the characteristics used in identification. They should be killed in a killing bottle, packed carefully, and shipped to an entomologist for identification and pinning.

Killing bottles containing cyanide, carbon tetrachloride, or ethyl acetate can be purchased from an entomological or science supply firm. If a commercial source is not available, killing bottles can be made by using ethyl acetate, trichloroethane, chloroform, benzene, or ammonia. Layers of absorbent material, such as rubber bands, are placed in the bottom of the bottle and a few drops of the liquid are poured into the bottle just before use. Crushed young laurel leaves and shoots also form a safe and satisfactory killing agent.

The most widely used preservative is 70 percent grain (ethyl) alcohol. Commercial ethyl alcohol (95 percent) must be diluted with water to obtain 70 percent strength. If ethyl alcohol is not available, ordinary rubbing alcohol may be used. In the absence of insect vial containers, "snap cap" aspirin-type bottles are suitable substitutes.

Care should be taken in packing and shipping insect specimens. Vials should be shipped with cotton around them in mailing tubes to prevent shaking and breakage. Adult specimens not preserved in alcohol should be placed between layers of cotton in a pillbox. The pillbox should be placed in a bigger box and surrounded with excelsior or crumpled paper. Always include a data slip with each specimen submitted. Data slips should include at least the following information: name of collector, date collected, geographic area, description and location of damage, host tree species, and remarks. First class mailing is preferable.

TECHNICAL ASSISTANCE SOURCES

For technical assistance with any insect or disease problem on state and private forests, please contact:

State Forestry Agency:
Address:
Telephone Number:

For technical assistance with any insect or disease problem on federal forests, please contact:

USDA Forest Service
Northeastern Area, State and Private Forestry
Forest Insect and Disease Management Field Offices:

	Responsible for the states of:
Forest Insect & Disease Management **359 Main Road** **Delaware, OH 43015** **Telephone: 614-369-4471**	**Delaware** **Indiana** **Maryland** **New Jersey** **Ohio** **Pennsylvania** **West Virginia**
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Forest Insect & Disease Management **1992 Folwell Avenue** **St. Paul, MN 55108** **Telephone: 612-642-5322**	**Iowa** **Illinois** **Michigan** **Minnesota** **Missouri** **Wisconsin**

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LIBRARY CARD

U. S. Department of Agriculture, Forest Service.
1979. A guide to common insects and diseases of forest trees in the northeastern United States. Northeast. Area State Priv. For., For. Insect and Disease Management., Broomall, PA. p. 123, illus. (USDA For. Serv., Northeast. Area State Priv. For. Publ. NA-FR-4)

Contains descriptions and color photographs of forest insects, diseases, and damage caused by common forest pests of the northeastern United States, with related information on weather factors, vertebrate animals, nematodes, and mites. Provides forest landowners and land managers with a guide for identifying these forest pests.

Keywords: Forest insects, forest diseases, nematodes, mites, vertebrate animals, tree damage, weather injury.

ODC: 453(74)

U.S. GOVERNMENT PRINTING OFFICE: 1979 652-395

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